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Examining the RAF's training chaos

Flight Instructing

Cost effective ways to the cockpit

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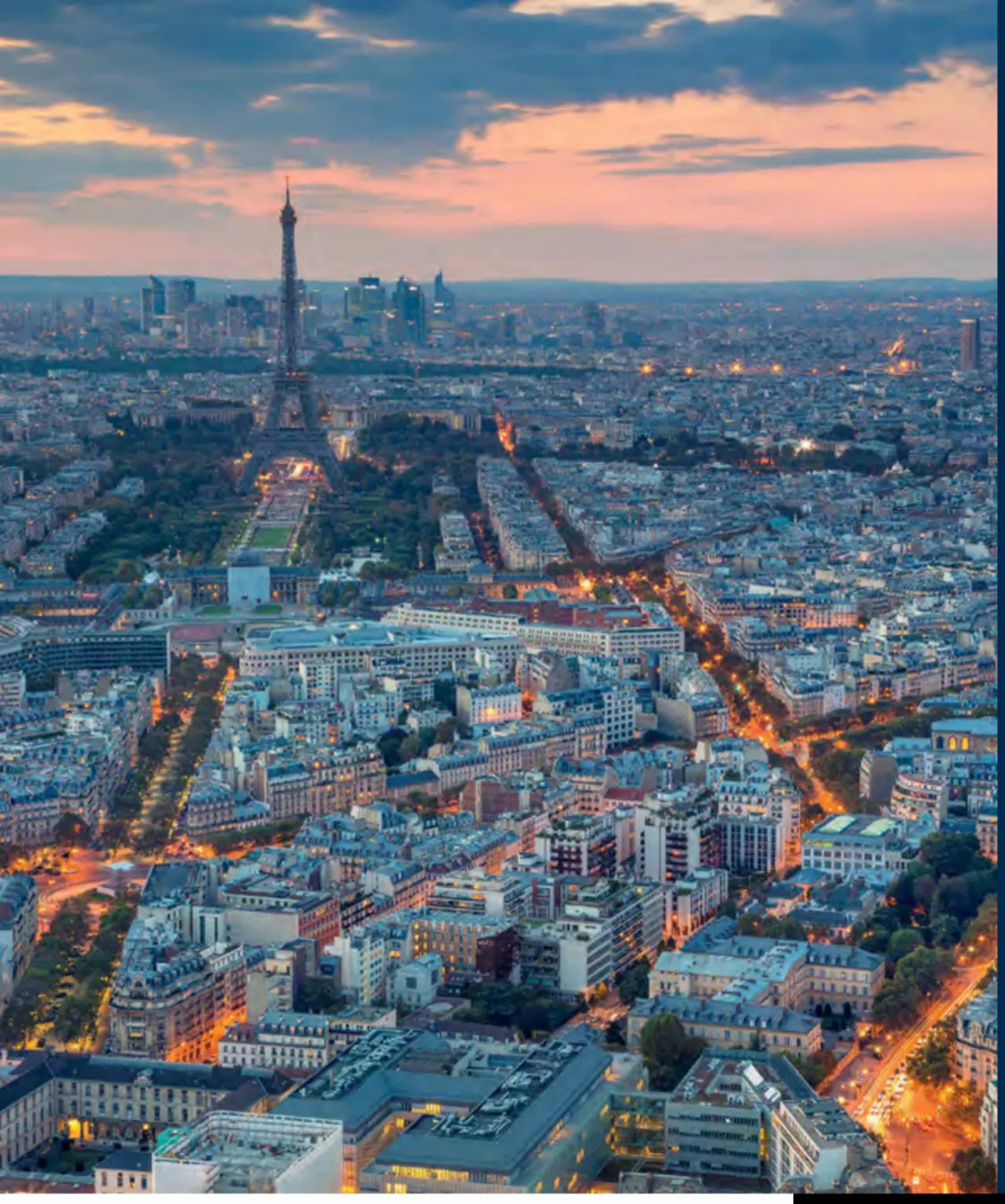

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Welcome

There's a growing global need for trained pilots, be it for the supersonic military fast jet cockpit or the flight deck of the 787 Dreamliner. According to US-based AeroGuard Flight Training Center, the commercial sector will need at least 649,000 pilots in the next 20 years, which works out at around 32,000 per year. With many airlines struggling to fill the gap created by this pilot shortage, several initiatives have been introduced.

Airlines have reduced their services to less popular and rural destinations because of the scarcity of crews. Increased salaries – significantly in the case of regional airlines – and faster routes to career advancement are initiatives that have raised the confidence of new pilots seeking long-term job security.

The dark days of COVID-19 bringing the industry to a halt are in the past. If ever there was one minor positive to come from the pandemic, it was the rapid increase in training technology. The commercial sector adapted and overcame as students remained on course at home. Once they could return to their flight training schools, upgrades were already in place, many graduated on time and headed off to the airlines.

Compare this to the state of military training. The inability to select a suitable primary trainer and offloading the syllabus to the private sector, only for student pilots to return to the military squadrons still in need of additional basic skills, has caused a huge backlog. For a potential RAF pilot seeking that fast jet cockpit, what should take two or three years is now predicted to take eight, during which time they may well be on hold, filling an administrative task for so long that they will need refresher courses to remain current; this, in turn, removes training aircraft for other students. While the RAF meets its operational commitments, the need to keep the best and brightest moving to Typhoon and F-35B slots must be addressed. Given the current global situation, investment in training is what is required now, not another internal review that keeps the office pen pushers busy.

Glenn Sands
Editor

LEFT:
The recruitment and training of pilots for the commercial sector is in great shape thanks in part to technology upgrades and efficient organisation at all levels BAA

FRONT COVER:
The latest look for Embraer's 'Profit Hunter' E195-E2 is called 'Tech Eagle', an aircraft set to be promoted to potential airline customers in 2024 Embraer

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See pages 18 and 19 for details

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Ray gun technology is here

The development of practical combat laser weapons has been the next weapon evolution sought by many nations for use on and above the battlefield. Several projects in the US and Russia have taken years to develop, with neither confirming anything much beyond development test concepts or, in some cases, later abandoning the application of such technology due to budget constraints, as in the case of the USAF's Boeing YAL-1, (a converted 747), airborne laser, intended to destroy theatre ballistic missiles in flight, this programme was halted in December 2011, because the system "does not reflect something that is operationally viable" at the time, according to Air Force Chief of Staff Gen Norton Schwartz.

A similar airborne flying laser mounted aboard a Russian Beriev A-60 was in development from the late 1970s to the early 1990s. It was abandoned after encountering similar problems to its USAF Boeing 747 counterpart. However, after more than 15 years in storage, Russia's airborne laser programme was reactivated in May 2009, with reports of a pair of converted A-60s occasionally seen airborne on test sorties. Their current flight status is unknown, although Russia is pursuing airborne laser technology, perhaps utilising a more modern air platform.

In contrast to both Russia and the US, Israel focussed its development on utilising laser weapons technology as part of its three-tier ground-based integrated air defence system. In this area, the nation has excelled since the mid-1990s.

Until recently, the jewel of Israel's air defence network was Iron Dome, which operates alongside Arrow 3/2 and David's Sling. Built by state-owned Rafael Advanced Defense Systems, Iron Dome (Kippat Barzel in Hebrew) uses radar to track incoming rockets and can determine whether the missile's trajectory threatens a protected area, whether a strategic site or a populated urban area.

If the rocket does pose a threat, a command and control centre can respond by launching its own Tamir missile to intercept it. The Iron Dome system is not configured to fire on rockets outside of a protected area, which means these are ignored and left to land harmlessly elsewhere.

Defence analysts agree that Israel has deployed at least ten Iron Dome batteries nationwide (the US has returned two additional systems to Israel), each of which can defend a 60-square-mile populated zone. Each battery has three to four launchers containing up to 20 Tamir interceptors.

Since its first use in April 2011, the Iron Dome has been "tested consistently", according to Israel's Defense Force spokesperson over the following years, with a 95.6% success rate against short-range rockets launched from within Gaza.

But Iron Dome does have a weakness, which Israel's enemies have learnt to exploit by launching hundreds of rockets nearly simultaneously in saturated strikes within several miles of the nation's borders. Such attacks confuse the system's ability to track and respond.

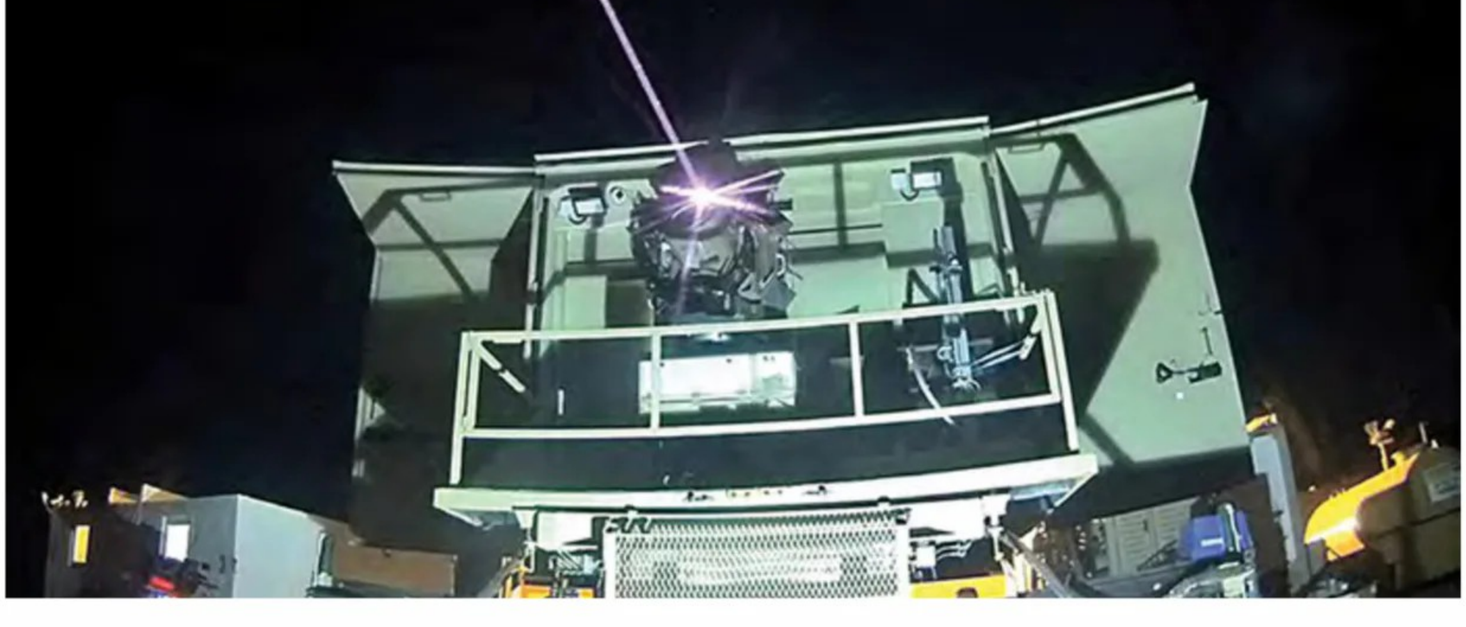
The second issue with Iron Dome is its operational cost, which is in part due to the cost of the Tamir missile itself as well as the multiple redundancies designed into Iron Dome to reduce failure rates and misfires. The estimated cost of an Iron Dome interception is approximately US$100,000 to $150,000. While the cost of

CLOCKWISE FROM RIGHT:

Iron Dome is combat-proven, with over 5,000 interceptions. The multi-mission system effectively counters rockets, mortars and artillery shells, as well as aircraft, helicopters and UAVs at very short range
Israeli Ministry of Defence

Israel revealed that in an earlier test, Iron Beam knocked UAVs mortars and rockets out of the sky
Rafael/Israeli Ministry of Defence

Iron Beam is a complementary capability to Iron Dome. Rafael makes the 100+ kilowatt weapon. Given the recent rocket attacks against Israel by Hamas, there's speculation that the laser system may have already seen limited operational service
Rafael/Israeli Ministry of Defence



defending Israeli land for the government is priceless, the need to counter more sophisticated saturation attacks using low-cost rockets led Rafael Advanced Defense Systems to resume their research and development on a laser-based missile defence system, which it first proposed in the early 2000s. Still, the project was regarded as not operationally mature, and Iron Dome was selected instead.

Rafael Advanced Defense Systems unveiled an early vehicle-mounted Iron Beam high-energy laser concept at the 2014 Singapore Air Show that utilised a twin multi-kilowatt solid-state laser, which was compatible with any radar. Opensource details describe Iron Beam as having a range of 7km and being able to destroy missiles and unmanned aerial vehicles (UAVs), or mortar shells, around four seconds after the dual lasers make contact with the target. With an estimated cost of around $2,000 per laser shot or less, according to some Israeli Defense Force sources. Despite Iron Beam's limited range, compared to existing missile defence platforms currently in use by Israel, it can bridge the gap where they are vulnerable. Iron Beam's 100kW laser must stay on the target for a few seconds to destroy it, but more than one beam can be used simultaneously to kill a swarm of armed UAVs or a salvo of rockets.

The attack by Hamas-led Palestinian militant groups on October 7, codenamed 'Al-Aqsa Flood', opened with a barrage of at least 5,000 rockets launched from the Gazza Strip against Israel, and such an attack exposed the limitations of the Iron Dome.

News footage from the region showed the nightly rocket attacks on Israel and Tamir rockets intercepting the Hamas-launched rockets. Amid the plethora of released night attack footage, some of which has been copied from gaming footage, it has to be remembered that to the human eye, a directed energy weapon does not create a visible beam of light unless there's a lot of humidity in the air which the laser will vaporise and create steam showing its path.

The advantage of using a laser for short-range defence, which allows a direct line of sight of the target, is that it won't run out of 'shots' or need to be reloaded, providing power can be maintained to the system. Given the ferocity of the conflict currently taking place in Gazza and the numerous rocket salvos fired into Israel during the opening days of the war, has Iron Beam seen operational service? If it did, it may be the first time a directed energy weapon has been used in combat. How effective it was, we may never find out. Still, given that the US, Russia, and China are actively pursuing similar applications of directed energy weapons, short-range air defence may only be the start of their use. **AI**

Start-up to

The hypersonic arms race is on, with the USAF currently having invested in more than 70 advanced hypersonic weapons programmes across a range of capabilities. Many of these focus on missile technology, with the ultimate goal of producing a missile that can operate above Mach 5 and manoeuvre at this speed, or above at the same time, on route to the target. Alleged hypersonic missiles in service, such as Russia's air-launched ballistic Kh-47M2 Kinzhal, once launched, follow a predictive straight path, making the weapon vulnerable to interception by an adversary, which has been in the case in Ukraine, with independently verified claims of the Kinzhals being intercepted routinely when fired from Russian aircraft. With the current inability to intercept any hypersonic missile, this means that the Kinzhal is simply a ballistic missile, and the claim by Russia that it's a 'hypersonic weapon' is, at best, questionable.

Currently, there is no technology out there, according to open sources, that can intercept hypersonic missiles, even when they conduct a straight flight trajectory. Still, if you can introduce the ability to change direction at hypersonic speeds, it's a game-changing capability.

It's why the USAF has invested so heavily in the technology with multiple companies, some of which are not the big familiar OEMs that the service relies on. With the new technology, the US has actively sought out new-generation tech companies, one of which is Atlanta-based Hermeus, created in 2018 to develop hypersonic aircraft for the commercial market which it hopes will lead to a commercial passenger-carrying aircraft named Halcyon that can cross the Pacific Ocean in just 90 minutes. While this may be some years off, what the company is doing right now, which has attracted

hypersonic

the USAF's attention and resulted in a US$60 million investment in 2021 to continue development in their hypersonic propulsion systems, is utilising off the shelf components currently available, and supplementing the technology gaps with 3D printers able to make components from titanium to create a hypersonic platform. Along with keeping the entire development process in-house, it reduces costs and removes the need to rely on external contractors. Effectively, Hermeus offers a reliable hypersonic capability at a vastly reduced cost compared to competitors, allowing for more systems, be it missiles or an unmanned aerial system (UAS), to be operationally available to an air force.

Another cost-saving move by Hermeus is to utilise proven ramjets instead of scramjet technology. Simultaneously, this may, in time, limit reach beyond Mach 5 in the long term, though the ability to manoeuvre at this speed will more than compensate tactically.

Among the three platforms in development by the company, Darkhorse has attracted the attention of the USAF, which again saw further investment with a US$950 million ceiling loan to explore the use of the hypersonic aircraft in what the service terms as an "advanced battle management system".

Hermeus views the Darkhorse as a payload-carrying hypersonic testbed that evolves into an operational UAS for strike and intelligence operations. The company took delivery of an F100-229 engine from Pratt & Whitney in June and is now looking at how to integrate that engine into Darkhorse. The F100 will take the UAS to Mach 2.8, after which the Hermeus-developed turbine-based combined cycle engine (TBCC) called Chimera II will take Darkhorse to Mach 5. The TBCC is a hybrid of a turbine engine and a ramjet, which allows for both low-speed and high-speed operations, with the benefit that Darkhorse can take off and land like a conventional aircraft.

Before an operational military UAS, Hermeus is working on a series of smaller remotely piloted platforms, Quarterhorse Mk 0 (plans are in place to have four test examples, Mk 0-4, each for a specific mission) to validate its research and the first development of the Chimera engine, which at only 5,000lb of thrust and a General Electric J58 in tandem with a ramjet will reach a speed of Mach 4 and above. Lessons learnt on this platform regarding performance and fatigue will be applied to later models before and incorporated into the Darkhorse and, eventually, Halycon.

Developing hypersonic aircraft quickly and cost-effectively by keeping as much in-house as possible may mean that Hermeus looks set to give the USAF an uncrewed 'true' hypersonic aircraft able to deliver asymmetric capabilities to the warfighter in the future. **AI**

CLOCKWISE FROM TOP:

Darkhorse might well be the first reusable hypersonic platform able to perform both strike and intelligence-gathering missions
All images via Hermeus

Chimera is a TBCC engine meaning it's a hybrid between a turbojet and a ramjet. Switching between these modes will allow Darkhorse, to take off from a regular runway and accelerate to high-Mach speeds. Chimera uses a pre-cooler to reduce the temperate of the air coming into the turbojet allowing the engine to draw out additional performance before switching to ramjet mode

The portfolio of hypersonic aircraft in development by Hermeus includes a proposed 20-passenger aircraft to a UAS able to strike targets at speeds of Mach 5

Mark Broadbent reports on the aircraft disassembly market and how the industry's sustainability push might create opportunities and challenges in the future

Condition assessments for engine valuations involve calculations of maintenance adjustments, replacement costs and scrap material resale values EirTrade

When a commercial aircraft reaches the mature stage in its life cycle, its owner must decide whether to overhaul the asset to add value to it and return it to market. The decision has many considerations, including the economic environment, market demand, operating costs, the specific asset's age and its maintenance record. Owners must decide if the financial gains from returning the aircraft to market justify the costs involved in making the required regulatory modifications to the aircraft so it can resume service.

If an owner decides it is not worthwhile to return the asset to service, the alternative is decommissioning, selling, disassembling and parting out any serviceable material (USM) to sell as spares.

Removing USM

Parting-out or teardown involves removing USM from an aircraft in accordance with the maintenance manual. Parts removed from an aircraft go to the maintenance shop for upgrade, recertification, test and inspection before release back into the supply chain for parts traders, brokers and maintenance, repair and overhaul (MRO) specialists.

Prime USM includes engines, limited life parts, components for quick engine changes, auxiliary power units, avionics, landing gear, large assemblies, doors, flaps, ailerons, actuators, pumps, wheels, brakes, tyres and cabin seats.

Engines are the most valuable items. The half-life maintenance values (HLMVs) of CFM International CFM56 and International Aero Engines V2500 turbofans on Boeing 737NGs and Airbus A320ceos, for instance, typically range between $3.8 million and $7.1 million per engine (depending on the specific model) according to a 2022 report by the consultancy IBA.

Certain factors affect engine parting-out, notably the overall supply-and-demand trends for replacement engines, fuel prices, the diversity of the engine type's operator base, the number of aircraft still flying using the engine and retirement profiles of similar engines. There are also factors specific to an individual powerplant, including capital costs, maintenance records and future ➔

LEFT:
An Airbus A320 undergoing disassembly by ASL at Kemble ASL

RIGHT:
Disassembly is underway at Kemble, where numbers have recovered from the pandemic low ASL

BOTTOM:
IBA predicts that more first-generation A320s will be retired during the second half of the 2020s ASL

requirements, spare parts availability, upgrade costs, residual value, aftermarket cost and long-term reliability.

Valuations are crucial in parting-out. According to IBA: "Part-out value is the actual or estimated selling price of aircraft, engines and or major assembly based on the value of marketable parts and components that could be salvaged for re-use on other aircraft or engines. Part-out value is primarily driven by the maintenance condition."

For engines, assessments for valuations involve calculations of maintenance adjustments, replacement costs and scrap material resale values. Maintenance adjustments themselves are based on 'green-time value' – the flight cycles remaining on life-limited parts – as well as maintenance shop visit costs and the value of the engine's expected time on-wing before it requires upgrade or rectification.

Benefits

Lee Carey, VP of asset management at EirTrade Aviation in Dublin told *Air International:* "Aircraft disassembly benefits various stakeholders by increasing spare USM components availability, reducing the cost of procuring these parts for end users, allowing aircraft owners to monetise assets, while ensuring that the remaining material is then recycled and facilitating a more efficient global supply chain."

Carey said airlines and MRO providers benefit from "increased availability of spare parts which can contribute to better operational efficiency, along with the cost savings which USM offers compared to new material offered by OEMs." He added that efficient levels of USM are useful for MRO companies in reducing turnaround times for their customers.

He said: "The analysis of components and systems during aircraft disassembly can provide valuable insights to OEMs and manufacturers for engineering enhancements, redesigns or improvements in future aircraft models or components."

Current trends

Mark Gregory is the founder and CEO of Air Salvage International (ASL) at Cotswold Airport in Kemble, Gloucestershire. He told *Air International*: "We are a founder member of the Aircraft Fleet Recycling Association. We ➔

"If an owner decides it is not worthwhile to return the asset to service, the alternative is decommissioning, selling, disassembling and parting out"


SPARROW

LEFT:
Engines are the most valuable used serviceable material on an aircraft ASL

BELOW:
An ex-Thai Airways International Boeing 777 approaches the final stage of disassembly ASL

> *"Less aircraft being disassembled reduces spare parts availability, which together with the higher demand, has raised prices for USM"*

work on best practices to disassemble aircraft and we're not owned by a big multinational. When the buyer buys an aircraft, they speak directly with me and they can work out a deal and make a decision there and then. Being in the business for a long time, I'd like to think we have a reputable company that has stood the test of time."

During a normal year before the COVID-19 pandemic, ASL disassembled between 40 and 50 narrowbody aircraft. In 2021, only 12 aircraft went through ASL's facilities, while 18 were processed in 2022. At the time of *Air International's* interview in October 2023, ASL had disassembled 32 aircraft, with another three or four due by the end of the year. Gregory noted: "Some of the aircraft that were due to be retired or stepped down will be utilised for a little while longer."

Two factors explain why. First, new aircraft deliveries have been delayed as manufacturers have reduced output due to raw materials, component shortages and labour constraints. Second, technical glitches with some newly delivered aircraft have led to higher-than-anticipated aircraft-on-ground (AOG) rates.

Gregory said that two aircraft he had been expecting to receive for disassembly by the end of 2023 had their leases extended by the operator and will remain in service rather than head to Kemble. Also, a 737 Classic freighter that arrived for disassembly has been turned around and returned to operations with a South African airline.

In July 2023, Pratt & Whitney disclosed that PW1100G Geared Turbo Fan engines would require inspection and, if necessary, repair after a durability issue was identified on discs in the high-pressure turbine. In a September 11, 2023 update, the company said: "Approximately 600 to 700 engines will be removed for shop visits between 2023 and 2026."

Gregory expects this issue will have a knock-on effect on disassembly in the near term. It is another reason for owners to retain assets for longer and/or return them to service so carriers can cope with capacity shortfalls. However, when the supply chain settles and new aircraft delivery rates do eventually increase, he anticipates "a glut of aircraft will come on the market, and prices will switch the other way."

Cyclical

According to IBA's analysis, the rate of retirements of older narrowbody airliners, including first-generation A320-200s and older Boeing 737NGs, will increase during the second half of the 2020s. Around 500 such aircraft will be phased out in 2025, but in the 2029-2033 timeframe, the number is expected to be more than 700 aircraft per year. Retirements of widebody aircraft such as older Boeing 747s and 777s and Airbus A330s will increase too, with approximately 150 expected to be withdrawn in 2025, followed by around 160 in 2026 and 2027, 190 in 2028 and 180 in 2029. IBA noted: "Quad-engine widebodies [are] retiring fastest, but the A330ceo will become the predominant retirement type by the 2030s."

In the meantime, EirTrade's Lee Carey pointed out: "We have seen a continuous increase in demand for USM components across all aircraft types in recent times with the increase in aircraft utilisation, maintenance activity and the evolving fleet renewal strategies of airlines."

Less aircraft being disassembled reduces spare parts availability, which together with the higher demand, has raised prices for USM. The IBA analysis notes increasing values for the latest engines: the HLMV for a LEAP-1A26 (for the A320neo), for example, rose from

$9.6 million to S$9.7 million between 2021 and 2022.

Resource management

Sustainability is a key theme in the aerospace industry. EirTrade's Carey observed: "Aircraft disassembly processes are sustainable by their nature as they promote the recycling and reuse of valuable materials from retired aircraft. These processes enable spare USM component availability, all while reducing waste, conserving resources and minimising the environmental impact of disposal. In addition, many aircraft operators and airlines opt to obtain their parts from disassembled aircraft due to their cost-effectiveness. The popularity of sourcing parts through a USM over buying brand new parts from OEM can also reduce consumption levels of new parts, and thus limit the carbon output from production. Furthermore, using USM components on aircraft reduces the number of new components that need to be produced."

Carey said EirTrade strives to be a complete solution provider for its clients: "Our ability to carry out services inhouse, such as disassembly for a variety of engine types (CFM56-3/-5A/-5B/-7B/-7BE) and all aircraft types, significantly reduces the project completion time as well cost of logistics. These integrated services simplify the processes for customers because we provide an experienced partner that can manage disassembly from conception to completion. We are able to disassemble a narrowbody aircraft in 15 days, and this efficiency is a significant advantage to asset owners, especially now when the demand for USM is exponentially increasing."

After any valuable USM is removed from an aircraft, disassembly specialists evaluate what is left of value to be recycled. Electrical connections, for example, are sent away to reclaim the gold and platinum in them. Gregory said any unwanted material is fragmented and sorted, adding: "We do not landfill anything. What can't be recycled is incinerated to produce power generation. The ash from that power generation is used in road-fill. This reduces waste, conserves resources and minimises the environmental impact of disposal. The components salvaged from aircraft disassembly also reduce the volume of new components, therefore reducing the consumption of material and carbon output of production."

Carbon challenge

Over the past decade, many new commercial aircraft have entered service with substantially higher proportions of advanced materials to reduce weight, ➔

fuel burn, emissions and overall operating and maintenance costs. Carbon fibre composites, for example, make up around 50% of the Boeing 787 Dreamliner and 53% of the A350.

In 2023, EirTrade announced it was the first company to disassemble two ten-year-old, early-production 787-8s. Carey told *Air International* that EirTrade "has focused on many newer technology aircraft and will continue to do so in order to service these markets for which there is very limited USM available."

Most aircraft with higher proportions of advanced materials are some years away from retirement and disassembly. Nevertheless, many aircraft with these materials pose questions about the procedures and processes to sustainably and cost-effectively disassemble them. The Aircraft Fleet Recycling Association (AFRA) stated: "It is estimated that by 2030, retired aircraft will feature high percentages of composites such as carbon fibre and other emerging materials. Both aircraft manufacturers and disassembly and recycling plants are actively developing strategies and processes to optimise these new materials' reuse and recyclability potential."

AFRA highlights further emerging challenges, specifically "the transporting of waste, the complexity of REACH legislation and the national implementation of end of waste legislation, which can result in a fragmented approach at the European Union level".

In broad terms, modern materials bring more complexity, time and cost in disassembly, as well as health and safety considerations such as dealing with carbon dust. ASL's Mark Gregory noted that while most of a 737 Classic can be recycled, that's not the case for carbon

"We are able to disassemble a narrowbody aircraft in 15 days"

Lee Carey, vice-president of Asset Management, EirTrade Aviation

‘Recycling at its best’

AJW Group’s MRO operations are located at AJW Technique in Montréal and its Battery Centre of Excellence at AJW Technique Europe in Slinfold, UK. The company’s chief commercial officer, Scott Symington, told *Air International* that parting-out is “basically, recycling at its best”.

The group’s disassembly process begins with an initial asset value appraisal and valuation of the remaining ‘green time’ and aircraft condition. A potential ‘harvest list’ is created using historical data, current repair costs and fair market value analysis.

Symington said: “We carry out a full aircraft and records audit to establish the maintenance history and the potential for aftermarket resale of the parts. The team then begins the disassembly, removing external parts and moving internally to components, systems, avionics and other high-cost equipment while cross-referencing each component’s associated paperwork and maintenance history from the harvest list.”

He continued: “Components are inspected and assessed for possible reuse; those that can be used in the aftermarket are labelled and catalogued into an inventory tracking and location system. Items that will be reused are then overhauled according to industry standards and may be tested and recertified to meet requirements. Once the overhaul, refurbishment and regulatory certification are completed, the components are marketed directly to customers and on aftermarket buying platforms.”

Symington added: “The safety and efficiency of the process are paramount. Strict regulatory, compliance and environmental regulations are upheld throughout these procedures, and hazardous materials and fluids are removed safely and according to the relevant regulations.”

ABOVE:
The AJW Group is one of the world’s leading independent component parts, repair and supply chain solutions provider, supporting over 1,000 airlines
AJW Group

RIGHT:
Scott Symington, chief commercial officer, AJW Group
AJW Group

composite aircraft: “We’ve gone forwards, but we’ve gone backwards in some areas.”

Gregory explained that, to be recycled, carbon fibre must be ‘clean’ – that is, it must not have any other material attached, such as screws, nuts, bolts, washers or paint. Recyclers also ask for carbon fibre to be cut in a specific direction, meaning disassembly will take longer than a narrowbody made from conventional materials, which can be taken apart in hours. Gregory said: “At the moment, the cost of extracting the metal items to get clean carbon fibre outweighs what you get. It’s not cost-effective to recycle it. That said, we are working with multiple carbon fibre recyclers who are exploring the possibilities.”

With the use of advanced materials rising as the industry seeks to fulfil its objectives of greener flight, advanced materials in disassembly will become an ever-more important issue. AFRA said: “Awareness needs to be further built in the industry of the importance of proper aircraft end-of-service management, so that the environment, worker safety, etc, are taken into account, not only the disassembly/recycling project.”

Gregory concluded: “In manufacturing anything these days, you need to think of end-of-life. You don’t want it to be an issue 15 or 20 years down the line. Manufacturers need to think about if a vehicle can be recycled and how it can be recycled.” **AI**

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German company Lilium is developing an industry first – a jet-powered electric vertical take-off and landing aircraft. **Mark Broadbent** reports

Jet eVTOL

The German company Lilium is notable among the various eVTOL aircraft – popularly dubbed air taxis – in development for passenger and cargo air transport in the emerging advanced air mobility market.

The company's eponymous aircraft is the first – and, so far, only – electric-powered air taxi to be powered by jet engines. The seven-seater stands apart from the crowd of prop-equipped eVTOL designs from developers such as Archer Aviation and Joby Aviation.

In September 2023, Lilium announced final assembly work was underway on the fuselage of the first Lilium Jet by project partner Aciturri. Meanwhile, Lilium itself had started producing the first engine for the aircraft at its headquarters in Wessling, near Munich.

The concept

Lilium intends to create what it calls "a sustainable and accessible mode of high-speed, regional transportation for people and goods". The company says the Lilium Jet will offer leading capacity, low noise and high performance with zero operating emissions.

In a 2021 blog, Lilium's chief technology officer Alastair McIntosh explained the company's approach: "Lilium envisions directly connecting inner towns and cities across ranges of between 40 and 200km at launch (and up to 500km longer term) at speeds of up to 300km/h while enabling significant time savings for individual passengers compared to alternatives.

"We call this Regional Air Mobility – not to be confused with Urban Air Mobility that typically seeks to connect points within a city over much shorter distances (<20km). In parallel, we have aimed for the highest payload of passengers (or freight) in the market since this translates into improved operating economics and, by extension, the flexibility to offer truly competitive ticket prices to customers."

McIntosh outlined the challenging set of requirements for its aircraft – vertical take-off and landing (VTOL) capability to enable inner city accessibility, low noise for urban operations and social acceptance, zero emissions, efficient cruise speed, a relatively high seat capacity to achieve attractive

Lilium Jet features forward canards, main wings and a distributed propulsion system providing vectored thrust
All photos via Lilium

economics, and scalability while maintaining a low ground footprint and low noise.

Disc load

McIntosh explained that the concept of disc load is fundamental to the Lilium Jet concept. Disc load is the total aircraft weight divided by the aggregate area of the rotors used during lift.

He said: "High disc load is associated with low lift efficiency in hover and a high-power requirement. Therefore, conventional eVTOL aircraft designs will attempt to minimise this attribute via larger diameter rotors but then at the expense of other attributes, such as noise, cruise efficiency and ground footprint."

McIntosh continued: "This leads to aircraft architectures that are either low-disc load, low range, multicopter concepts or more complex open-rotor, higher-range concepts. Both directions offer low-noise emissions at fixed payloads, but the payload of such systems cannot be scaled for the same noise profile.

"When you step back, the end result with this conventional approach is to adapt existing non-electric VTOL concepts to make them electric effectively."

Vectored thrust

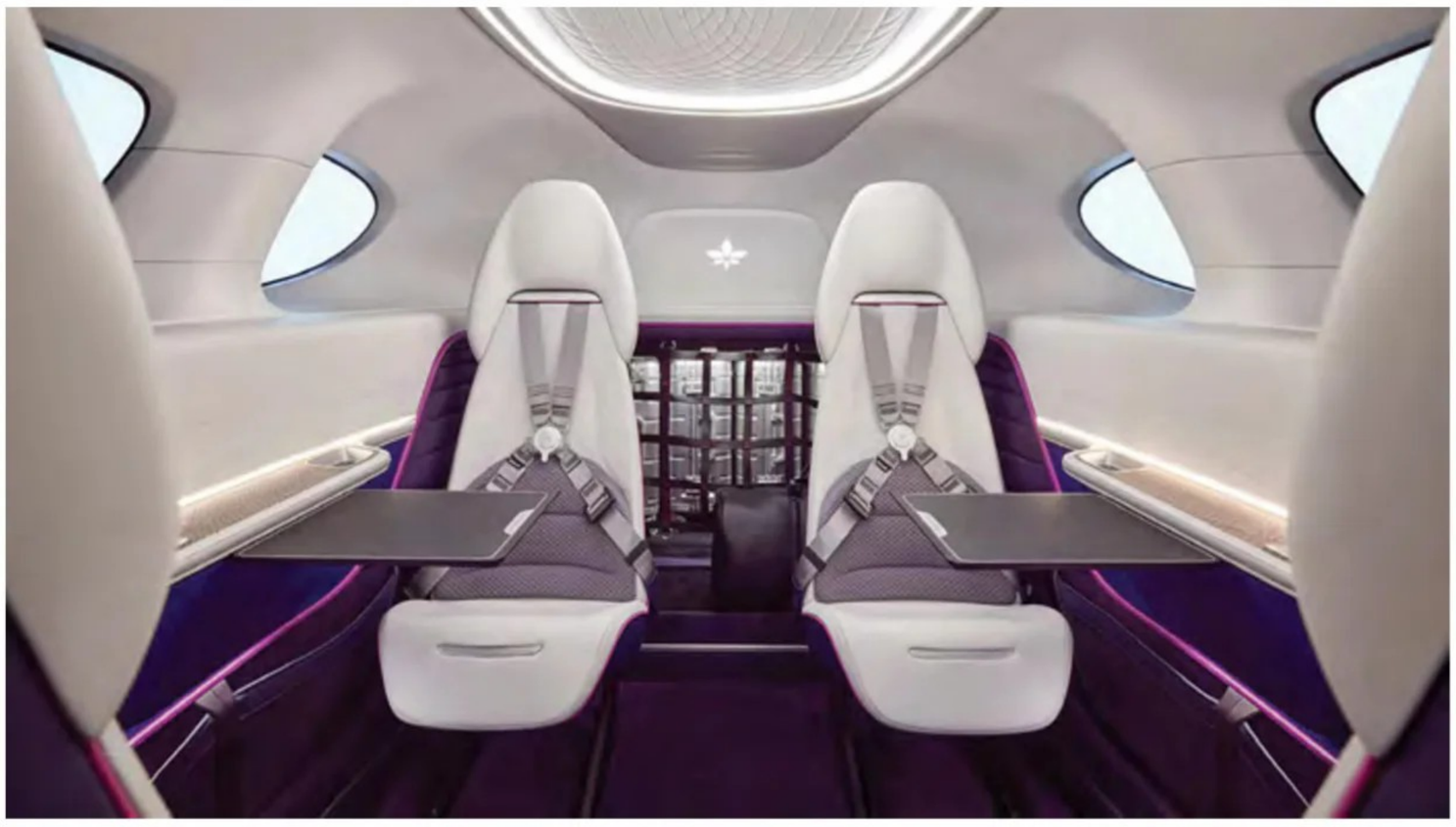
McIntosh wrote in his blog that Lilium "approached this challenge from the other direction: exploiting a flight envelope more typical of a commercial fixed-wing aircraft rather than rotorcraft".

The Lilium Jet features forward canards, main wings and a distributed propulsion system providing vectored thrust. The main wingspan is limited to less than 14m to enable the use of existing helipads. "Simple by design, there are no ailerons and no need for a vertical stabiliser. The landing gear is fixed, and there are no hydraulics," McIntosh said.

The proprietary propulsion technology developed for the aircraft is called Ducted Electric Vectored Thrust (DEVT), where electrically-driven jet engines integrated into the wing flaps provide thrust and vector control, enabling precise manoeuvring through every phase of flight. Lilium says the technology offers "advantages in payload, aerodynamic efficiency and a lower noise profile".

McIntosh wrote: "Directional stability is provided by active electronic differential thrust control. The aircraft is controlled through a fly-by-wire avionics system. The main wings generate 60% of the lift, the canards 20%, and the remaining 20% is generated across the fuselage. The canards and wings are positioned as far apart as practicable to enable the aircraft to be stable in pitch."

The DEVT system itself consists of 36 individually controllable flaps that also serve as lifting and control surfaces; each flap contains a ducted electric fan. McIntosh explained: "The 36 ducted fans are embedded in a 1:2 ratio on the canard to the main wing. Embedding the ducted fans into the wings eliminates the need for dedicated nacelles, reducing weight and minimising aerodynamic drag loss. The flap is rotated by an integrated servo unit, which can rotate the whole flap unit for controllability during hover and cruise flight. The flaps only receive two signals, fan speed and flap angle, by which the aircraft can be controlled throughout the flight envelope via thrust vectoring."



ABOVE:
The Lilium Jet will be able to carry up to seven passengers

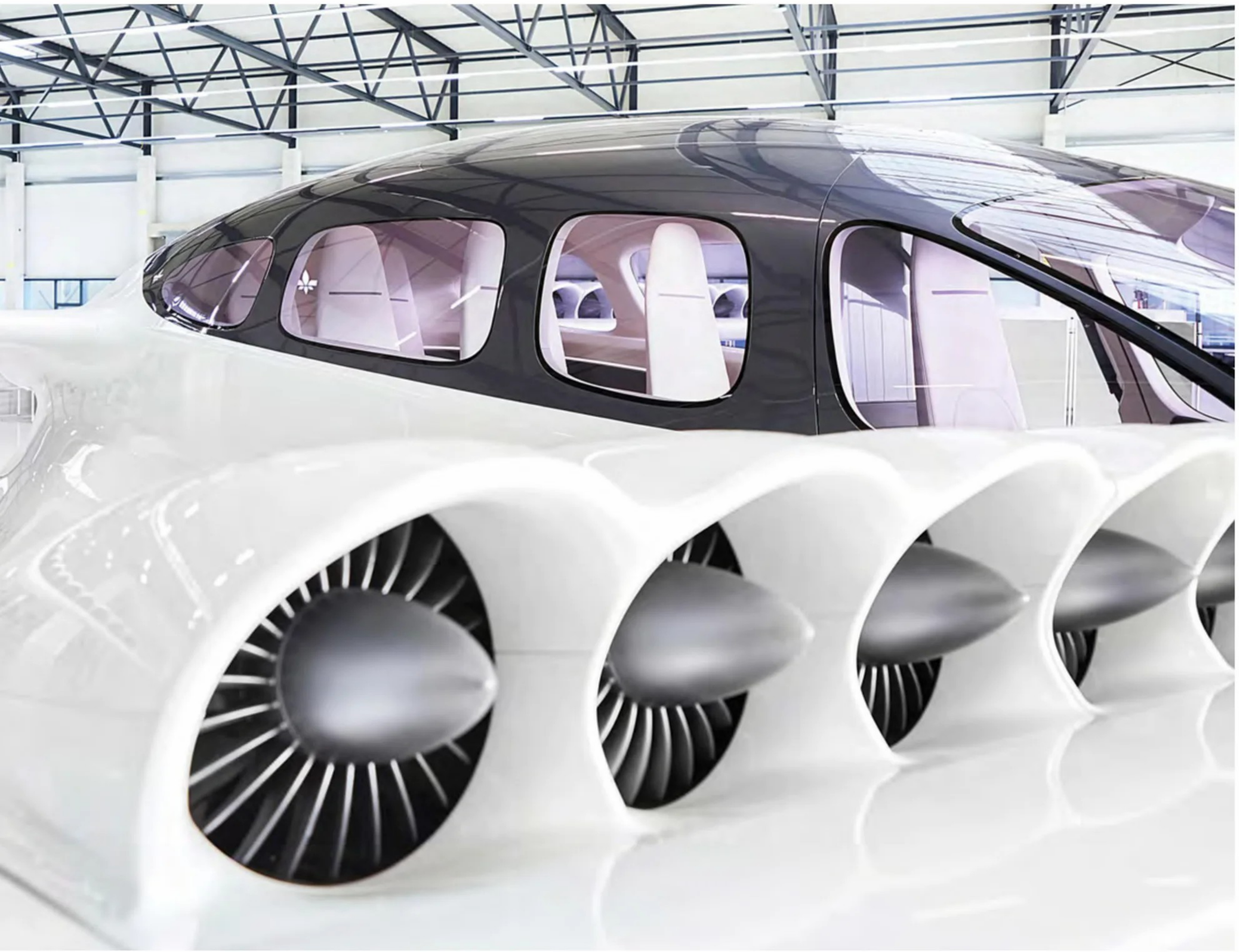
TOP:
The propulsion system consists of 36 ducted fans, each serving as lifting and control surfaces

Different flight profile

McIntosh states: "A common misconception of eVTOL aircraft is that they must emulate the mission profiles and performance characteristics of helicopters – that they must be capable of hovering for a long time as a central feature of their mission purpose."

Lilium's mission profile is different; he pointed out: "The goal is to simply connect two geographical points as quickly and efficiently as possible, like a commercial airliner, to maximise time spent in the efficient cruise flight phase and to minimise take-off and landing (i.e., hover) time."

Therefore, The Lilium Jet will have a different typical flight profile than a



helicopter. McIntosh explained: “During take-off, we are only hovering [for] approximately 10 to 25 seconds, and we also assume approximately 20 seconds during a standard landing phase, while keeping approximately 60 seconds as reserve. This leads to an overall total hover time (on a typical mission) of 60 seconds in the most power-hungry flight phase.”

The Lilium Jet, he noted, “demands approximately two times more power during this phase compared to an open rotor concept on the market at equal weight. However, since this phase is quite short, it represents approximately 5% of the mission energy budget.”

McIntosh wrote: “The transition to forward flight and re-transition back to hover take approximately 20 seconds each. The total hover, transition and re-transition time consumes <15% of the total stored energy on a typical mission or <20% if including reserves. The major part of the aircraft’s flight envelope consists of the climb, cruise and descent phases in which the efficiency is more than ten times higher than during hover flight (i.e. the power consumption is a tenth of hover in this phase). In this highly efficient phase, the Lilium jet flight physics resembles a commercial fixed-wing jet aircraft.”

McIntosh said this profile “underpins, in part, the decision to go with small ducted fans and thus accepting a higher disc load. We intentionally spend only a very short time in take-off and landing so we can optimise the aircraft design for the dominant period of a flight, which is cruise.

“Despite two times higher power consumption in hover than an equivalent open rotor concept, this increased power demand is compensated by optimising cruise flight performance, which only requires 1/10th of hover power and also makes up to more around 90-95% of the flight time.”

Ducted fans

McIntosh said Lilium quickly understood electric ducted fans were the essential technology suited to such a flight profile.

Ducted fans offer “roughly 40% more efficiency compared to an open propeller at [the] same discload”, he said, “since nearly all blade tip losses and swirl losses are removed thanks to the duct and the presence of stator vanes”. The efficiency improvement, he added, “goes some way to compensate for the higher power demand”.

Ducted fans are less noisy, McIntosh explained: “The duct casings and acoustic liners contain the noise, stopping it from radiating in all directions, as it does with open propellers,” which is, he added, “a key enabler” for Lilium Jet’s planned inner-city operation.

McIntosh said Lilium had spent significant time optimising the fan blade and stator vane aerofoil design to reduce noise further. The duct generates a straight inflow onto the fan blades, and the stator takes out a swirl, which enables relatively low rotor blade tip speeds (below Mach 0.45).

Duct and acoustic liners shield and dissipate tonal and broadband noise, while ducted fans require less power at the same disc load and thrust levels due to the duct’s “significant performance advantages”.

McIntosh said that high-fidelity computational fluid dynamics (CFD) software analysing airflow fluctuations in depth enabled the blades to be designed both to reduce noise and optimise

ABOVE:
Lilium envisions directly connecting inner towns and cities across ranges of between 40 and 200km

OPPOSITE:
Collins Aerospace supplies the Lilium Jet's inceptors, the sidestick system used by the pilot to control the aircraft and its systems

aerodynamic performance. The analysis tool and models were validated with actual data measured during the test campaign of the company's five-seater technology demonstrator aircraft flown during 2021/22.

McIntosh said: "The measured noise levels not only correlated well with pre-test predictions but also gave maximum peak values in the 60-65dB range, at 100m distance, without the addition of acoustic liners."

The embedded fans in Lilium Jet's wing mean a smaller surface area is required for engines, which in turn helps reduce drag. McIntosh said DEVT means there is no need for standard aerodynamic control surfaces such as tails, ailerons and rudders, further reducing structural weight and drag.

He said: "The aerodynamics of the fan are designed to be most efficient during hover flight. As the thrust required for cruise [is] only a tenth of that required for hover flight, the flow field around the fan changes significantly. This would lead to the consequence of a significantly reduced aerodynamic efficiency during cruise flight compared to hover flight.

"However, at the exhaust of the ducted fan, we use a variable area nozzle which changes the exhaust cross-sectional area during the flight and thereby guarantees high levels of fan efficiency in all phases of the mission profile. For hover, the nozzle is fully open; for cruise, the nozzle area is reduced."

Power density

Battery technology is a fundamental aspect of all new-generation electric aircraft. For eVTOLs, specifically, batteries must deliver both the energy density to provide range and sufficient specific power to support hover. Minimum state-of-charge (SOC) – in other words, the total accessible energy available in a battery cell – is essential.

McIntosh explained: "One of the challenges in designing the battery system for the Lilium Jet is the provision of high power by the battery cells at low SOC. Battery technology from earlier than 2014, which we used in our demonstrator, allowed for a minimum SOC of approximately 30-40% only, as the discharge capacity of the batteries did not provide sufficient power at lower levels of the SOC."

He said: "Today, this is mitigated by state-of-the-art cell technology applying more advanced anode material, such as silicon, which increases the discharge capacity of the battery cell and, thus, the power provision at low SOC is significantly improved."

While battery cells for the five-seat demonstrator could not provide sufficient power and energy, McIntosh said technology development had enabled Lilium to "pivot the aircraft architecture" and increase payload to seven seats while achieving a SOC of 10-15%.

McIntosh said: "The energy team at Lilium have been working closely with our battery cell technology partners to deliver cell performance suitable to fulfil our mission profile and in a package that can be produced on a full-scale manufacturing line.

"By making use of our custom cells and chemistry with our aerospace grade supplier, we will be able to expand the range of the Lilium Jet to approximately 250km at entry into service."

Assembly and testing

Regarding the latest developments, Lilium's chief operating officer, Yves Yemsi,

said: “The start of propulsion assembly represents a significant step towards industrialising the Lilium Jet. In the coming weeks, we will be systematically working towards validating our manufacturing capabilities and preparing to deliver the propulsion units for initial aircraft integration and type-certification testing.”

In the first phase of assembly, the DEVT propulsion system’s rotating parts (including the shaft, magnets and titanium compressor fan) are assembled and mated with the associated static components, such as the e-motor stator and guide vanes, before they are integrated into the engine.

In the next phase, the engines will be integrated into the Lilium Jet’s propulsion mounting system, the unique flap structure that forms the rear part of the wings and front canards housing the DEVT system responsible for vertical and horizontal flight.

Meanwhile, Aciturri is building the first Lilium Jet fuselage at its Valladolid factory in Spain. It plans to deliver the completed fuselage to Lilium’s facilities in Wessling by the end of the year so Lilium can start the final assembly of the first aircraft. Seven Lilium Jets will be used for flight testing and certification.

A Lilium statement explained: “This latest phase of Lilium’s programme demonstrates the success of the strategic supplier partnership between Lilium and Aciturri, leveraging Aciturri’s proficiency in the design and manufacturing of high-quality aerostructures. It follows a comprehensive industrial program review conducted in late August 2023 in which leadership from Lilium and Aciturri reviewed and greenlighted the initial industrial production components and process.”

Maria Eugenia Clemente, CEO of Aciturri Aerostructures, commented: “Aciturri is committed to playing a leading role in the transformation of sustainable regional air mobility… We are fully aligned with Lilium’s vision and design and are delighted to have evolved our partnership to such a foundational stage towards the birth of the Lilium Jet.”

Assembly work follows extensive testing of propulsion subsystems delivered by other suppliers. These include the custom e-motor, developed and built in collaboration with Denso and Honeywell; the titanium compressor fan created and built with Aeronamic; and electric motor bearings, made in collaboration with SKF.

In July 2023, Lilium completed testing a full-size prototype Lilium Jet fan and stator at Jetpel’s facilities, one of Germany’s leading aviation technology centres, to confirm the fan design’s operating parameters. Additionally, testing has started on a prototype e-motor for its mechanical, electrical, and thermal performance.

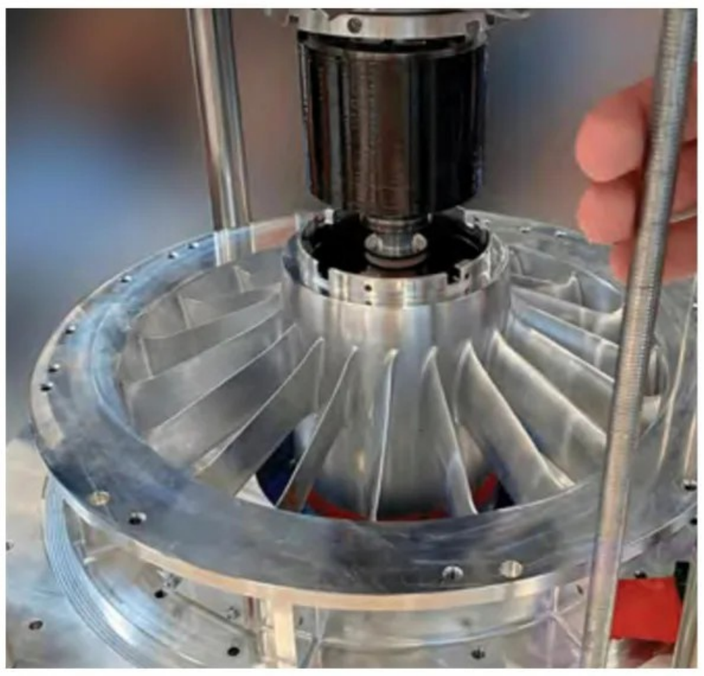
Benchmark for eVTOL

Lilium has received orders for more than 600 examples of its aircraft from customers, including ASL Group and Globe Air. Another notable customer is helicopter services company Bristow Group, which has ordered 50 examples that it plans to deploy in the US and Europe. A partnership will see Bristow provide Part 145 maintenance services for the aircraft.

In June 2023, Lilium received the Federal Aviation Administration G-1 Certification Basis necessary for type certifying the Lilium Jet; the company received European Union Aviation Safety Agency certification basis in 2020.

Lilium CEO Klaus Roewe hailed the September 2023 announcements as further progress towards what he called “the dawn of a new, sustainable jet era”.

Roewe said: “Thanks to the unique propulsion system and aerodynamic jet architecture, I believe the Lilium Jet will set the benchmark for the eVTOL industry.” **AI**



ABOVE:
One of the propulsion system’s 36 fans

RIGHT:
Lilium plans to use seven aircraft for testing and certification

TOP:
A five-seat technology demonstrator flew in 2021/22

Gripen E evolves and adapts

The full potential of Saab's Gripen is finally being realised with new upgrades to the airframe. **Jon Lake** explains what these improvements bring to the fight

Recent photos of several Gripen E aircraft show some subtle but significant changes to the trailing edge of the wing. The original trailing edge control surfaces have been replaced by larger units, which have changed the wing planform from being a cropped Delta with a 'straight' trailing edge to having a more tapered shape, with a rearward extension of the trailing edge from the wing root outboard to the tip.

Saab has not officially announced the modification, which was 'spotted' by sharp-eyed enthusiasts in recently released photographs – most notably of Saab-operated development aircraft 6002.

The change is similar to that made to the Eurofighter Typhoon as part of the Aerodynamic Modification Kit (AMK), which also saw the installation of small fuselage strakes and leading-edge root extensions, as well as increased-area elevons. On the Typhoon, the modifications were reported to have collectively increased maximum

The wing upgrades introduced to the Saab Gripen E fighter will allow pilots with the Swedish and Brazilian air forces to carry significantly heavier firepower on enhanced air-to-air missile launchers, along with improved performance that will make it ahead of the game to some Western fighters
Saab AB, Linus Svensson

lift by some 25%, providing higher longitudinal stability at higher angles of attack and allowing enhanced asymmetric load-carrying capabilities while also leveraging increased turn rates, a tighter turn radius, and an enhanced ability for the pilot to 'point' the nose at low airspeeds. The AMK modifications were tested on the German Instrumented Production Aircraft IPA7 in 2015 and are now expected to form part of the ongoing 'Long Term Evolution' package of modifications.

The modifications to the Gripen trailing edge will almost certainly increase lift and manoeuvrability, but this was not the driver of the modification, as Saab's head of business unit Gripen, Johan Segertoft, explained to *Air International*.

"At an early stage in the development process, an opportunity was identified to improve Gripen's heavy load-carrying capabilities as a clear benefit to future operations. A decision was made to implement this enhancement as quickly as possible. We have updated the software and some modifications affecting canard and elevon surfaces. These changes bring immediate benefits, prove our ability to reliably deliver growth and consistently improve the aircraft's potential for the future," Segertoft said.

Though he referred to modifications "affecting the canards", these do not seem to have been changed in size or shape, but their range of travel may have been adjusted, or software controlling them may have been tinkered with.

"Gripen E's performance envelope has now been enhanced and further expanded with an increased ability to integrate heavier and more complex loads to meet future mission requirements."

"The feasibility of this enhancement was identified in the early stages of Gripen E development using Saab's model-based design techniques. Further exploration in the early trials programme underlined the benefits for future operations, and in 2021, it was decided to make these improvements to the baseline design."

As well as 6002, the new trailing edge elevons have been seen on development aircraft 6011 and the first aircraft delivered to the Swedish Air Force, 603.

"The first aircraft in the latest configuration flew in the second half of 2021. There are currently 16 Gripen E fighters flying in Sweden and Brazil. More will be delivered soon. The new design features have already been added to some of these aircraft, and successful flight trials have been completed. The enhanced design will become the standard configuration in the future in all production aircraft for Sweden, Brazil and other customers," Segertoft observed.

"The cornerstone of the Gripen design concept is its ability to adapt rapidly

JAS39E Production

C/N	Serial	Variant	Operator	Status	Notes
Demonstrator					
39-7	39-7	Demo	Saab Aircraft	Active	
Prototypes					
39-8	39-8	JAS39E	Saab Aircraft	Active	
39-9	39-9	JAS39E	Saab Aircraft	Active	
39-10	39-10	JAS39E	Saab Aircraft	Active	
Production standard					
396001	4100	JAS39E/F-39E	to Brazil	Active	as 4100 (F-39E)
396002	6002	JAS39E	Saab Aircraft	Active	grey splinter camo
396003	6003	JAS39E	Saab Aircraft	Active	grey splinter camo
396004	6004	JAS39E	FMV	Active	
396005	6005	JAS39E		Active	FAB 4101?
396006	6006	JAS39E		Active	FAB 4102?
396007	6007	JAS39E		Active	FAB 4103?
396008	6008	JAS39E		Active	FAB 4104?
396009	6009	JAS39E		Active	FAB 4105?
396010	6010	JAS39E		Active	FAB 4106?
396011	6011	JAS39E	Saab Aircraft	Active	
396012	6012	JAS39E	Saab Aircraft	Active	
	603	JAS39E	FMV	Active	

and effectively to changing needs. We continue to enhance the aircraft in ways that can be seen and not seen as we incorporate new technology and new requirements. Fighter aircraft must be able to evolve quickly, effectively and affordably to meet the needs of their users."

Though the new modification is primarily intended to improve Gripen's heavy load-carrying capabilities, it seems likely that it will also reduce wing loading, increase lift, and thereby improve turn performance. At the same time, the larger control surfaces should also improve agility. This will please those Gripen critics complaining that the aircraft is lacking in this area compared to (say) the F-16. A former RAF Typhoon pilot and test pilot described the Gripen cockpit and man-machine interface as the best he had ever flown. Still, others suggest that the original Gripen C lacked kinematic performance compared to the F-16. Some were disappointed that the evolution to the Gripen E standard did not see a more dramatic improvement to both installed thrust and wing area. The latest modification will go some way towards quietening some of the critics. There is no doubt that the Gripen E's sensor suite is already far 'ahead of the game', with its Leonardo ES-05 Raven AESA radar incorporating an innovative repositioner to give a vast field of regard, while the Finmeccanica – Selex ES providing an advanced 60 Skyward G-IRST (infra-red search and track) system.

When Saab delivered the first series-produced Gripen E aircraft (603) to the FMV (Försvarets materielverk, the Swedish Defence Materiel Administration) on Friday, October 6, 2023, it had the new, revised wing shape. Also, it featured new main and emergency batteries, with two Li-Ion batteries replacing three thermo batteries. The battery change represents, a Saab source told me, "a more recent and different type of example of Gripen E evolving to stay ahead".

The new 24-volt, 36 amp-hour Lithium Ion batteries were designed specifically for the Gripen E-series by American manufacturing company EaglePicher Technologies. These have an extremely low-temperature capability and an extended operational cycle life, allowing a longer 'time on wing' and reduced maintenance. The batteries incorporate integrated battery charging and an integrated battery management system with a bi-directional communications bus. The latter enables better situational awareness for the pilot and maintenance personnel.

The new batteries use advanced performance power electronics technology and reduce aircraft weight and maintenance costs.

Johan Segertoft commented: "This successful change, that we have undertaken together with our customer, further improves Gripen's redundancy and robustness. It is this type of new business that we will see in the future, i.e. that we, together with our customer, will further develop our systems and products."

"We are introducing a new modern technology in Gripen that creates growth potential. The battery technology is developing rapidly, and there we have traction from the hugely growing electric car market, which will ensure continued development in the area," he said.

The newly delivered aircraft will be operated by the FMV before eventually being handed over to the Swedish Armed Forces. Lars Tossman, head of Saab's Aeronautics business area, said: "I am very happy and satisfied that we have achieved this important milestone towards deployment. It is an important milestone, and more deliveries will follow shortly."

Mattias Fridh, Head of Delivery Management at Gripen Design,

ABOVE:
The new wing planform has been significantly extended, resulting in a more tapered appearance, with larger inboard flaperons, as seen here in this plan view of test aircraft 6002
Saab AB, Linus Svensson

OPPOSITE:
The original wing configuration had a short forward swept section at the wing root and then a straight trailing edge outboard to the wingtip
Copyright Saab AB

Gripen E, the second generation JAS 39

Once known as the Gripen NG (Next Generation) or Super JAS, what became simply the Gripen E was initially conceived as an upgrade configuration intended to be applied to 60 Swedish Air Force Gripen Cs. However, it was later decided that the aircraft would be newly built, using some components recovered from redundant JAS 39Cs.

A two-seater aircraft, 39-7, designated as the 'Gripen Demo', was ordered in 2007 as a testbed for various Gripen E upgrades – including the General Electric F414G engine. The Gripen Demo aircraft made its maiden flight on May 27, 2008. The aircraft subsequently demonstrated its ability to supercruise on January 21, 2009, reaching a speed of Mach 1.2 without afterburner.

Assembly of the first pre-production Gripen E (39-8) began in July 2013, and the aircraft made its first flight on June 15, 2017. By then, Brazil had joined the programme, Saab having made a successful bid to fulfil the Brazilian F-X2 fighter requirement in 2013 and signing a contract with the Brazilian government for the development and production of 36 aircraft in October 2014.

The Brazilian order included eight two-seat F-39Fs, which are being developed and produced with the participation of Brazilian technicians and engineers. Construction of the two-seat prototype is currently underway in Brazil.

The first Brazilian F-39E Gripen (the first production-standard aircraft, 4101) made its first flight at Linköping on August 26, 2019. The aircraft was formally handed over to the Brazilian Air Force for flight testing on September 10, 2019. However, it was not until August 20, 2020, that Major Cristiano de Oliveira Peres, a Força Aerea Brasileira test pilot, flew the aircraft for the first time from Saab's Linköping airfield. The aircraft was then shipped to Brazil and transported to Navegantes International Airport, from where, on September 24, 2020, it was flown to the Embraer factory airfield at Gavião Peixoto, in São Paulo state, for further testing. The flight test centre at Gavião Peixoto is linked to Linköping to allow test data to be shared across the test fleet.

Brazil originally ordered 36 Gripen E/Fs, consisting of 28 single-seat F-39E Gripen Es and eight two-seat F-39F Gripen Fs. Four further aircraft were subsequently added to the Brazilian order. On February 1, 2022, the Brazilian Air Force commander, Carlos de Almeida Baptista Júnior, told a local newspaper that Brazil was in the initial planning phase of negotiations for a second batch of 30 Gripen E/Fs to take the total to 66 aircraft. On May 23, 2022, he announced that this second batch would consist of 26 Gripens, having added four aircraft to the first batch. The first 13 Gripen Es for Brazil are being manufactured in Sweden. Still, Saab and Embraer inaugurated a local production line for Brazil's remaining Gripens at the Embraer factory in Gavião Peixoto on May 9, 2023.

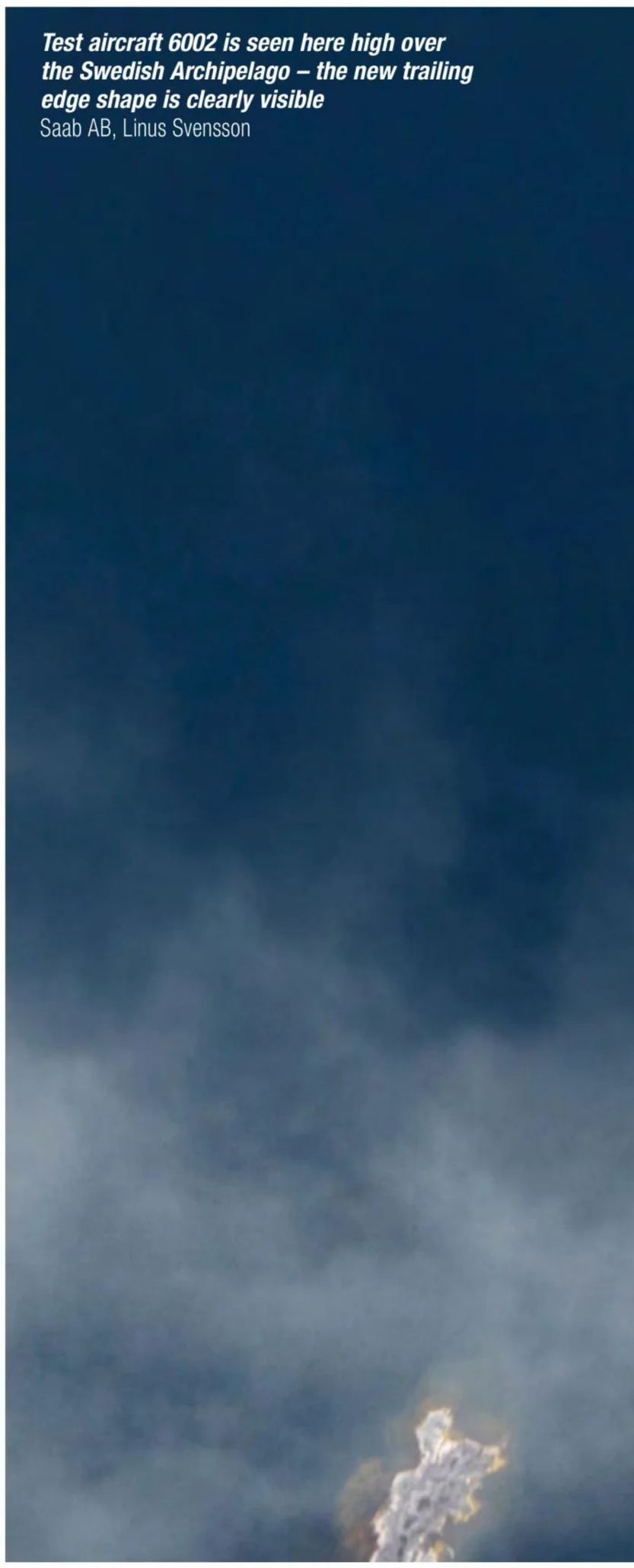
The first Gripen E prototype, 39-8, is being prepared for engine testing at Linköping Saab AB, Per Kustvik

Of the 40 now on firm order, Brazil has received six series production aircraft (4101-4106), and the air force hopes to begin operations with the 1st Air Defense Group (1º GDA) at Anápolis air base before the end of the year.

Sweden's requirement is for 60 JAS 39E aircraft. However, some expect this to increase in light of the changed security environment in Europe following Russia's invasion of Ukraine – mainly if Sweden transfers some of its 92 or so remaining JAS 39C/D aircraft to Ukraine. Sweden had planned to retain between 40 and 60 of these, upgrading them – perhaps with AESA radar and new weapons.

The first production-standard Swedish Gripen E aircraft (6002) made its maiden flight in November 2019. They were the first of seven Swedish-based test aircraft (in addition to the Gripen Demo, 39-7, and three prototypes, 39-8, -9, -10) used for the joint verification and validation programme.

The developmental test and operational test and evaluation programmes will be conducted together from Saab's Linköping factory airfield and FMV's test centre near Malmen. There is an ambitious target for service entry on January 1, 2025, with the F7 wing at Såtenäs, the operational conversion unit. A first operational squadron is expected to form within the revived F16 wing at Uppsala in 2025.



Test aircraft 6002 is seen here high over the Swedish Archipelago – the new trailing edge shape is clearly visible Saab AB, Linus Svensson

revealed that the FMV has now received all parts of the weapon system required for it to operate the Gripen E. FMV technicians independently have received Gripen E training and are ready for flight line operations and maintenance. Support and training systems have already been delivered, and those parts of the support systems delivered in 2022 were upgraded to match the new configuration in August this year. It is assumed that when Saab was granted a Military Restricted Type Certificate (MRTC) for Gripen E in the air-to-air role in November 2022, this covered the new configuration, attesting that the aircraft met all the airworthiness and flight safety requirements set by the Swedish Military Aviation Safety Inspectorate (FLYGI) and Brazil's Industrial Fostering and Co-ordination Institute (IFI). This certification cleared the way for the Swedish and Brazilian air forces to become official operators of the Gripen E (known as the JAS 39E in Sweden and

the F-39E in Brazil), a status up to then reserved for Saab. Certification for the air-to-surface role will follow further trials.

Saab believes the key to modern warfare is rapid adaptability to maintain technological superiority over the most challenging adversaries. The segregated core avionics architecture of Gripen E was conceived from the outset with adaptability and flexibility at its heart. The new avionics architecture separates flight critical systems from tactical systems in the Main Mission Computer, allowing the latter to be changed without the need for time-consuming and labour-intensive verification and re-validation of the airworthiness of the Gripen-E, unlike other fighter platforms in service today. This facilitates the rapid and iterative integration of new capabilities, such that new functionality can be swiftly added without compromising the availability of the aircraft. Existing algorithms and hardware can be rapidly replaced or changed within very short time frames. This unique approach makes Gripen E a continuously evolving system, almost like a living creature. By late 2022, new software releases were being test-flown on the Gripen E every four weeks on average.

A new Strategic Partnership agreement between the UK and Sweden signed in Visby, Sweden, by UK Prime Minister Rishi Sunak and his Swedish counterpart, Prime Minister Ulf Kristersson, on October 13 contained the surprising revelation that the British and Swedish governments would co-operate in promoting international sales of Saab's JAS 39 Gripen E and "the associated weapons package".

The Gripen was designed with considerable UK input and includes some 30% UK content by value. The Gripen E features a UK-developed Raven ES-05 active electronically scanned array radar and several UK-supplied weapons, including the MBDA Meteor beyond-visual-range air-to-air missile and probably the Spear 3 and Spear EW missiles.

Sweden was briefly expected to be a participant in the UK-led Future Combat Air System programme but stepped back into more of an 'observer role' when it was concluded that Sweden's combat aircraft requirements were "out of sync" with those of the Anglo-Italian-Japanese Global Combat Aircraft Programme (GCAP) to develop the sixth-generation manned fighter at the heart of GCAP. This was because Sweden had invested heavily in the development and procurement of the Gripen E. There has been speculation that Sweden could rejoin the FCAS programme – at least insofar as the planned adjuncts and effectors are concerned, which could be helpful to assets alongside Gripen E.

The Gripen E (or a developed derivative of it) could even form the basis of a second manned fighter type within the overall FCAS system of systems. **AI**

Pilot pathways

BAA Training is one of the few EASA ATOs delivering Ab Initio and Type Rating training
BAA Training

It's not that long ago that aspiring airline pilots took lessons on weekends at their local flying club with progress toward a Private Pilot Licence (PPL) depending on finding the money for the lessons.

While that's still possible, the fastest way to an airline cockpit today is through a pilot cadetship, a university degree course or a corporate flight training organisation. Depending on the country, there are various ways to fund the £100,000 or so it takes to get a Commercial Pilot Licence (CPL), but however it's done, the high cost is still a barrier for many.

When the pandemic grounded aviation, most airlines let pilots go or placed them on furlough. When they needed them back, significant numbers declined the offer, either because they had found new careers or had decided to retire early. Airlines are now scrambling to rebuild their pilot ranks, which has increased

For those seeking a flying career in commercial aviation, it can be an expensive process in the early years, but the hardships are rewarded with an 'office' that will take you around the world, as **Michael Doran** explains

opportunities and opened more pathways to find talent, whether cadets or pilots stepping up to larger or new aircraft types.

Career ladder

No matter where you start on the ladder, the first real milestone is obtaining a CPL (or its equivalent), which in the UK means you will have achieved at least 200 flying hours and passed the CPL or ATPL (Airline Transport Pilot Licence) theory examinations.

From there, the hours needed for direct entry to an airline increase, often to 1,500 hours, with other endorsements and certifications, as required. As a sign of the times, Virgin Australia is recruiting 737 First Officers with a minimum total flight time of 500 hours, while Qantas has the same requirement for the Second Officers it recruits.

While airlines may have their flight academies, it is not unusual for the training to be provided by an Approved

"By integrating AI technology into our virtual training, we have significantly enhanced the quality of our examination processes, resulting in a higher success rate for students"

Marijus Ravoitis, chief executive officer, BAA Training

flight simulators (FFS) and flight training devices (FTD) for Airbus A320, Boeing 737 MAX, 737 NG, 737 CL and 747-400 types.

The new facility in France opened in September near Paris-Orly Airport with three full flight simulators: one Boeing 747-400 and two 737 NG types, with an Airbus A320 FFS scheduled to begin training in November.

BAA CEO Marijus Ravoitis told *Air International* that the company is making significant investments to expand its Flight Training Organisation infrastructure for Ab Initio training, including establishing new flight bases and acquiring additional aircraft resources.

He said: "These strategic investments are aimed at enhancing our operational capacity, enabling us to meet the increasing demand for pilot training services effectively. In doing so, we are better positioned to support airlines in preparing a greater number of new pilots and is a sign of our commitment to growth and excellence within the aviation training industry."

The new facility in France required an investment of €30million (£26m). BAA said the training centre was primarily inspired by its collaboration with Transavia France. The centre offers simulator wet and dry lease services and is forecast to train around 2,000 pilots annually.

Airlines needing to quickly get pilots trained on new aircraft types or have their licences made current have kept BAA's training facilities busy for some time. Pilot training and certification are part of aviation's supply chain, so meeting changing demand and a commitment to customers is something BAA takes very seriously.

The CEO added: "There is a major increase in demand for type rating courses, and BAA is actively devoting significant resources to meet this

Training Organisation (ATO), which caters to specific airline programmes focused on producing future airline captains for local and international carriers, the flying component of tertiary programmes and integrated programmes for individuals.

BAA Training

BAA Training is one of the few EASA standard Training Organisations in Europe delivering both Ab Initio and Type Rating training. It has its headquarters and a training centre in Lithuania, with training facilities in Spain, Vietnam and France and a training consultancy centre in India.

BAA Training (BAA) also has access to a network of more than 69 partners' full flight simulators in 29 locations worldwide and offers more than 45 training programmes. It operates a variety of full

growing need. To maintain our position as a top supplier of complete aviation training solutions, we rigorously address the needs generated by this increased interest in particular forms of training."

Pilots holding a PPL or CPL must acquire a Frozen ATPL, the theoretical training required for a relevant Type Rating and an airline pilot position. BAA has developed ATPL Theory Virtual, which allows pilots to study for the 13 ATPL exams from anywhere in the world.

This is not just a self-study online course, as professional and experienced lecturers who fully comply with EASA regulations and standards deliver the ground lessons in real-time. Pilots can access instructor-led lectures, interactive in-class group discussions, group assignments, peer-to-peer conversations and regularly updated EASA training materials.

"By integrating AI technology into our virtual training, we have significantly enhanced the quality of our examination processes, resulting in a higher success rate for students seeking Authority certification," said Ravoitis. "Our virtual training approach is innovative and well accepted by airlines seeking to hire well-prepared and competent pilots from BAA."

Air International asked Ravoitis if the pilot shortage had impacted instructor numbers, and he replied that the whole aviation industry is grappling with the challenge of recruiting qualified instructors to meet the rising demand for training services, with BAA actively seeking new instructors: "We have instituted a motivational system that sets us apart in the industry. This approach aims to attract and retain the top talent in the field, offering a compelling proposition for individuals considering a career as aviation instructors."

As well as all the technical aspects,

ABOVE:
CAE utilises a mix of Full Flight Simulators and Flight Training Devices
CAE

LEFT:
CAE partners with global airlines for their flight training needs
CAE

BAA distinguishes itself through a set of core values that Ravoitis said resonates well with its customers and partners, "including a culture of flexibility, responsibility, ambition, value creation and a profound commitment to people".

BAA Training is a member of the Avia Solutions Group, the world's largest ACMI (Aircraft, Crew, Maintenance and Insurance) provider with a fleet of 192 aircraft. The Group also provides various aviation services, including maintenance, repair and overhaul, pilot and crew training, ground handling and different associated services.

QANTAS Group Pilot Academy

Australian flag carrier Qantas is an excellent example of the pilot pathway, with its recruitment focused on two streams: direct entry for CPL or ATPL licence holders or through its Qantas Group Pilot Academy for Ab Initio pilots or those with a PPL.

The Pilot Academy involves a 12-month course covering theory and practical components delivered in partnership with Flight Training Adelaide (FTA). Flying training is done with the Diamond DA40 single-engine and the DA42 multi-engine aircraft with 155 hours in the air and ten on a simulator.

On successful graduation, students will qualify with the licences and ratings they need to either join one of the Qantas Group airlines – which includes Qantas, Jetstar and regional carrier QantasLink – or to enter commercial aviation in an alternative way.

The licences are issued by Australia's Civil Aviation Safety Authority (CASA) and include a CPL-A, Multi-Engine Command Instrument Rating (ME IR), Multi-Crew Co-operation (MCC) and ATPL Theory.

Qantas has a scholarship programme that aims to provide equity-based grants to support diversity and attract more females and First Nations people into the airline's pilot programme. The scholarship supports a student with on-site accommodation costs, but the cost of the training is not included.

Qantas is actively recruiting for its Pilot Academy students and direct-entry Second Officer positions. It also has a Future Pilot Program that allows students at the Academy to be mentored by experienced Qantas Group pilots.

Graduates will receive an invitation to attend a Qantas Group Accelerate Assessment Centre and, if successful, may be eligible to join the Qantas Group as a pilot with QantasLink or Jetstar. The airline also runs regular virtual Pilot Information Sessions, presenting opportunities across the Group and putting candidates in touch with its Talent Acquisition Team.

CLOCKWISE FROM ABOVE:
The Qantas Pilot Academy prepares pilots to fly its international fleet of widebodies
Qantas

The long-term goal for many commercial pilots is long-haul flying types such as this 787-9 Dreamliner belonging to Qantas
Qantas

Cadet pilots learn their flying skills on a mix of single and twin-engine aircraft
CAE

CAE – Training and simulators

Canadian company CAE is a name familiar to many for its Full Flight Simulators and Flight Training Devices, but it also operates the world's largest civil aviation training network. It offers training from those without flying experience to CPL, ATPL and MPL (Multi-crew Pilot Licence) level.

CAE provides training for various airline cadet programmes, including easyJet, American Airlines, Jetstar and AirAsia, as well as courses for type ratings, instructor certificates, licence proficiency checks and many more. It is also the largest pilot recruitment agency in the world, working to match pilots with more than 70 clients in 35 countries.

With such a vast array of services and technology, *Air International* asked CAE regional manager for Cadet Solutions, Americas, Jonathan Gerber, what sets CAE apart and why its airline pilot training partnerships are so successful. He replied: "CAE's airline cadet programmes are successful because we work very closely with airlines to understand their needs, tailor the training programme to their requirements and work jointly to ensure standards of training and professionalism are adhered to and enforced.

"Our programmes all rely on a solid pre-training screening and assessment scheme and high-quality airline-focused training. We don't just train for a licence; we train for a future job."

Earlier this year, CAE released its '2023 Aviation Talent Forecast', a ten-year outlook of demand for pilots, aircraft maintenance technicians and cabin crew in civil aviation. Airbus and Boeing have forecast a need for around 600,000 new pilots by 2041, but the benefit of CAE's outlook is its shorter timescale – what is needed by 2032.

CAE found there is a need for 284,000 new pilots to be recruited and trained over the next ten years, with 252,000 for commercial aircraft and 32,000 for business aviation. The Asia-Pacific region accounts for 33% of that demand, North America 29%, Europe 18% and the Middle East 10%.

CAE has doubled its global footprint in the last ten years and offers more than 300 full-flight simulators and 170-plus aircraft across 60 training centres. It is also developing Mixed Reality Training devices, like the CAE 700MXR, that will complement existing FTDs of various types.

The CAE 700MXR combines physical reality and digital environments to enable interactions with the real world among virtual objects. It uses enhanced reality, high-precision head and hand tracking and the accurate, tactile feel and physical experience of the flight controls, instruments and displays.

While it may vary by location, CAE uses Piper and Diamond aircraft in its flight training programmes. It mainly relies on flight training devices, replicas of those aircraft, for Ab Initio training.

For type rating programmes, CAE uses full flight simulators, FTDs and Integrated Procedures Trainers (IPT) that provide aircrews with realistic procedural training in a three-dimensional spatial environment.

Within its simulator network, CAE has FFSs for aircraft types from ATR, Airbus, BAE, Boeing, Bombardier, de Havilland Canada, Embraer, Fokker, Lockheed Martin and Saab, which covers most of the commercial airline aircraft flying today.

"We don't use augmented reality devices as FTDs already allow us to get the maximum amount of credit under the FAA regulations, and adding VR or other devices would add cost without reducing flight hours further," Gerber said. "We also have software that simulates air traffic control, and we have Garmin G1000 desktop devices for the cadets to practise on."

LEFT:
The Ascension Academy opens the door for cadets to join the ranks of Air Transat pilots
Air Transat

BELOW:
Newly qualified First Officers with Air Transat will find themselves flying types such as this A321LR when they begin their commercial flying career
Air Transat

"The programme is designed for pilots with little or no flying experience who will earn their wings at CAE's Phoenix (US) facility and have the opportunity to join Air Transat"

The global pilot shortage is impacting the ranks of flight instructors, and this is something CAE is seeing in most of its markets. However, the US market is somewhat shielded by the 1,500-hour minimum rule that keeps the instructor pipeline flowing.

"Due to the 1,500-hour rule and the high demand for airline pilots, there is a high number of young people who become instructors to accumulate their 1,500 hours by instructing," he added. "The 1,500-hour rule ensures flight schools have a ready supply of instructors."

CAE can graduate around 1,500 pilots annually and runs 11 airline cadet programmes worldwide. Gerber said that since 2021, the "phone has not stopped ringing" and CAE has a steady stream of cadets wanting to become pilots and airlines wanting capacity for Ab Initio training.

The time is right

No matter where they end up in the industry, most pilots enter the profession because they are obsessed with aviation and want to fly. Usually, getting into the industry is the most challenging part, but right now is one of those times when the stars are aligned for aspiring pilots.

The pandemic changed the structure of pilot ranks, with many leaving either by choice or because their airline could not afford to keep them on during the grounding. Almost a year after travel restrictions disappeared, many airlines still have aircraft on the ground because they can't find the pilots to fly them.

Cadet programmes are back in vogue, direct entry opportunities are no longer a pipe dream and airlines are hiring, so for the first time in many years, the door is wide open for motivated people to follow their dreams.

Opportunities like those at Qantas and Air Transat are replicated at many other airlines, and with 284,000 new pilots needed over the next decade, now is the time to join the pathway. **AI**

Air Transat wants you!

In September, Canadian airline Air Transat and CAE announced the launch of Ascension Academy, a new cadet training programme to establish a pipeline of qualified pilots trained to the highest standards.The programme is designed for pilots with little or no flying experience who will earn their wings at CAE's Phoenix (US) facility and have the opportunity to join Air Transat as second-in-command pilots on the airline's fleet of Airbus aircraft.Successful applicants will be admitted to the Ascension Academy programme and will receive a conditional letter of employment from Air Transat for a second-in-command position. CAE Phoenix runs more cadet training programmes than any other flight school globally, including Southwest, American Airlines, easyJet and Japan Airlines.The programme is based on a US Federal Aviation Administration (FAA) initiative that leads to a Private Pilot Licence, Instrument Rating and a Commercial Pilot Licence with Multi-Engine rating. Cadets will progress through their first solo flight and instrument phase and conduct Line-Oriented Flight Training (LOFT) to prepare them for their airline careers.CAE Phoenix, Arizona, has more than 75 single and twin-engine aircraft, with the Piper aircraft fully airconditioned and equipped with Garmin G1000 avionics. Phoenix has more than 300 days of sunshine and 350-plus flying days a year with a mix of busy Class B, D and E airspace and large desert expanses.After completing the Phoenix training, the newly minted pilots return to Canada and convert their licence from the FAA to Transport Canada before completing their type rating with Air Transat and beginning second-in-command positions. Air Transat operates a modern fleet of Airbus A321, A321LR and A330 aircraft on routes to 60 destinations in 25 countries across 25 countries in North, Central and South America, the Caribbean and Europe.

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Just as nature abhors a vacuum, the airline industry feels similarly about an aircraft-on-ground (AOG) situation, where revenue-generating vehicles are prevented from doing their job. Knowing ahead of time that a module, part or component is likely to fail shortly means airlines can prepare and ensure that a necessary replacement can be accomplished in a just-in-time manner, thus keeping the aircraft airworthy as much as possible.

This process of advanced diagnostics, known as predictive maintenance (PdM), is becoming more prevalent across the industry, with many airlines and OEMs adopting such solutions. Seth Babcock, head of Tech Ops Solutions and Data Analytics at Collins Aerospace, offers his thoughts on the key elements of a predictive maintenance programme and the drivers that make the business case for its adoption.

"Predictive maintenance is an important application of data analytics in aviation. This involves using data to predict when aircraft maintenance is likely to be needed, allowing for proactive repairs and replacements before a problem occurs," Babcock confirms. "By implementing predictive maintenance programmes, airlines can reduce the risk of equipment failures and ensure that their aircraft operate at peak performance.

"Beyond helping to prevent maintenance events, predictive maintenance has other potential benefits. In the area of repair costs, by proactively addressing part failures before they occur, ancillary damage to other parts of the

Predictive maintenance offers a crucial step forward

Diagnosing problems in advance will help the airline industry to keep aircraft flying and prevent costly groundings. **Bernie Baldwin** learns about predictive maintenance from leading practitioners

Honeywell's analytics will now help AVIATAR's predictive health analytics to predict the behaviour of systems and components during operation
Honeywell

aircraft may be prevented, turning a major repair into a minor repair," he continues. "Then, when scheduling maintenance, by timetabling the event, the operator can ensure that the right people, material, and tooling are in place to complete the task. This reduces strain on the overall network and supply chain."

Targeted troubleshooting is also helped. "Often, troubleshooting involves trying to recreate the fault during ground operations. This is sometimes impossible because of different operating conditions. Because the recommendation is based on data, the action the operator takes is often targeted to the specific component and failure mode," Babcock adds. "Finally, by preventing the maintenance event, an airline can help pilots and ground crews focus on specifically identified areas of repair and maintenance instead of drawing attention away to chase unknown failure situations, which can help improve the overall safety of the operation.

"The benefits of data analytics and predictive maintenance in aviation are numerous. By improving the reliability of aircraft and equipment, airlines can reduce the likelihood of delays and cancellations while also increasing safety for passengers and crew," he declares.

AJW Group's technical director, David Miret Mora, believes that predictive maintenance holds excellent potential for aviation. However, he thinks its adoption faces complexity due to regulatory gaps and the absence of a structured framework. "Presently, aviation regulations lack a defined PdM structure, creating a significant barrier to its acceptance across different aviation key players," he explains. "To unlock its benefits, a PdM framework is imperative to align stakeholders' interests and establish a consistent maintenance strategy.

"Historically, aviation maintenance followed structured schedules, with pioneers like Nowlan and Heap introducing reliability-centred maintenance (RCM) in 1978, leading to the MSG-3 logic methodology [created by the Air Transportation Association (ATA), the forerunner of Airlines for America (A4A)]. Recent innovations, like aircraft health monitoring (AHM) systems, have transformed maintenance practices," Miret Mora adds. "However, a definitive PdM technology framework remains undefined, necessitating a comprehensive approach to address limitations, consequences, and industry-wide challenges.

"Traditional maintenance emphasises scheduled maintenance to achieve cost-effective airworthiness. PdM offers an analytical approach, potentially optimising maintenance by preventing premature or delayed component replacements," he remarks. "Nevertheless, formal research is needed to validate its superiority.

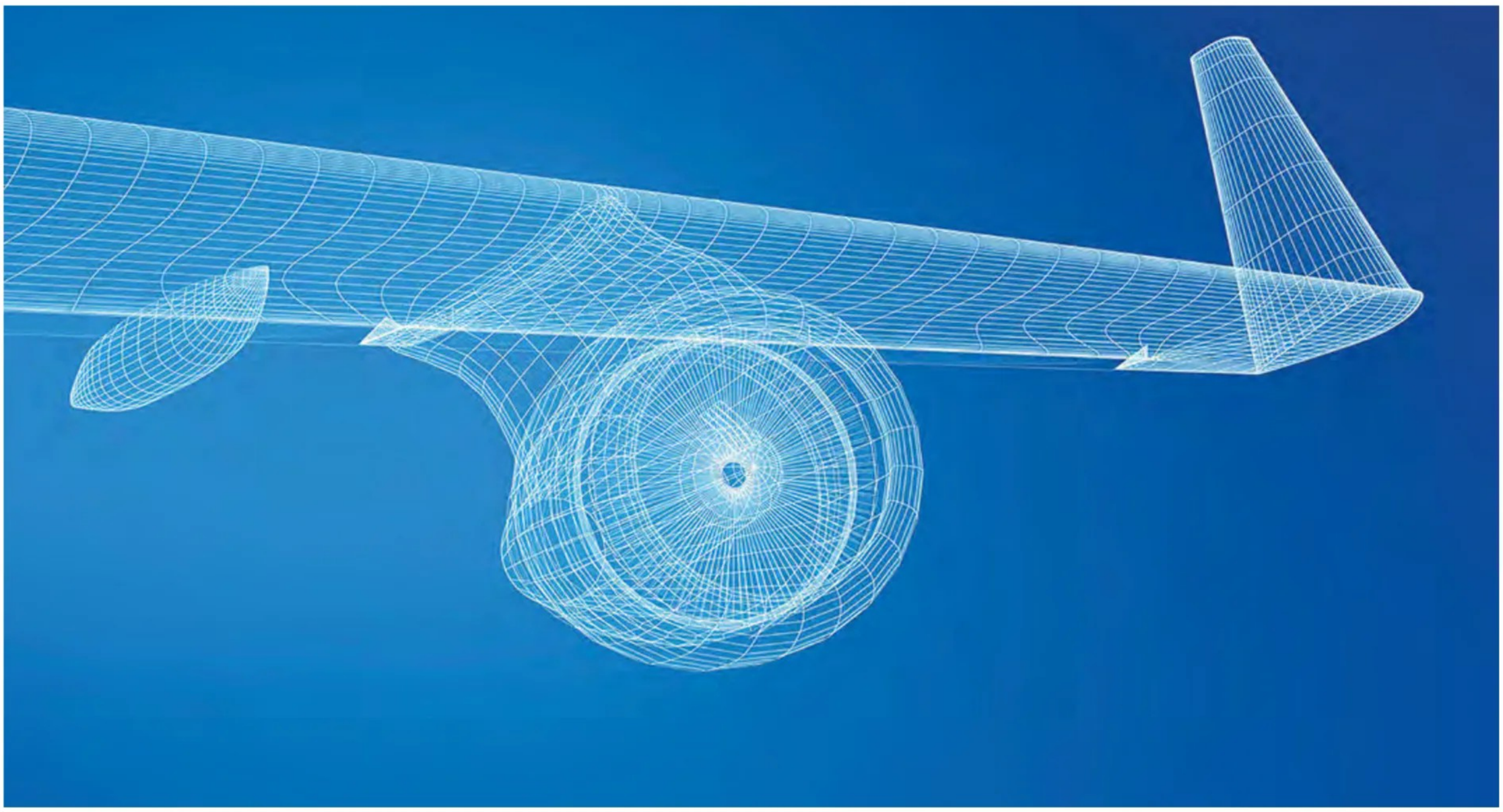
"Digital solutions, including PdM, are gaining traction in aircraft maintenance, driven by their potential to enhance operators' availability and reduce airline operational costs. Airlines are eager to invest, but the challenge lies in gaining acceptance from regulators, MRO providers, suppliers, OEMs, and other stakeholders.

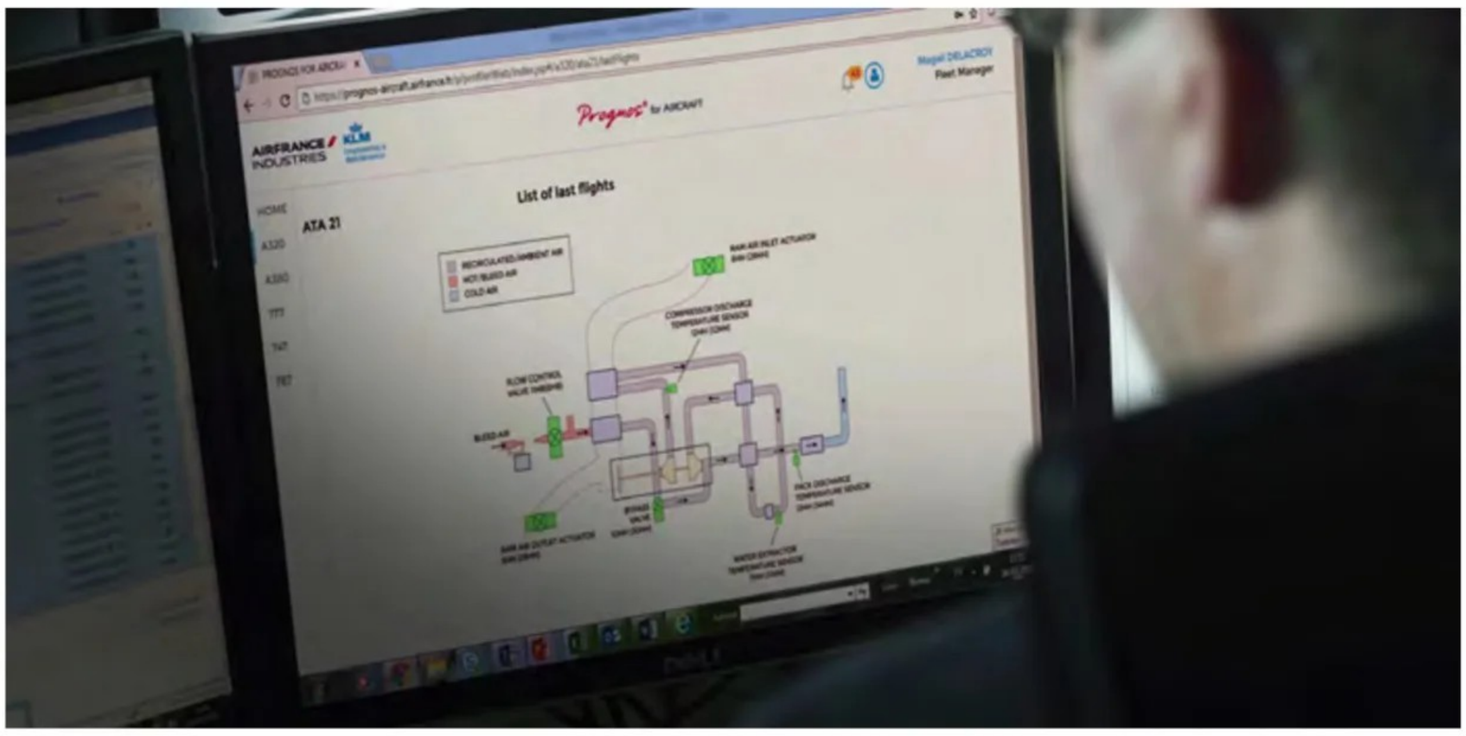
"Airlines stand to benefit most from PdM, but its successful implementation requires industry-wide readiness," Miret Mora argues. "Unanticipated consequences may emerge at both on-wing (such as unnecessary line maintenance activity) and off-wing maintenance levels (such as a potential increase in removals or higher NFF (no fault found) rates due to an early removal and not being able to detect the failure mode). The lack of unity among stakeholders further complicates matters. PdM's emergence in aviation maintenance is still in its early stages, raising fundamental questions that demand collaborative solutions."

For Steve Schoonveld, director of product management, Connected Aircraft at GE Aerospace, a predictive maintenance programme is a three-legged stool of processes, people and data. "Predictive maintenance is a cultural shift, which requires changing parts or performing maintenance before something breaks. This is a process change for most operators, and having a champion that understands and supports that shift is key. Truly effective programmes embed predictive maintenance as part of the day-to-day operations," he observes.

"More tactically, successful teams must have domain expertise, specifically an understanding of aircraft design, operations, and data science. It's essential to understand how a system is designed to work, how it is actually used in operation, and then how to pull the data needed.

Lastly, quality data sets are only valuable when put in the hands of a skilled team," Schoonveld emphasises. "Recording the right data and then getting a consistent and timely flow





CLOCKWISE FROM OPPOSITE:
Honeywell formed a partnership with Lufthansa Technik in 2023, licensing the analytics to the latter for deployment in its AVIATAR platform
Honeywell

Engine health monitoring is a vital part of predictive maintenance
Lufthansa Technik

Seen by AJW Group technical director, David Miret Mora, as an early adopter of predictive maintenance, Air France Industries KLM Engineering & Maintenance has developed its own solution, Prognos
KLM Engineering

enables all the downstream predictive analytic processes. We often encourage customers to start with their data, whether sourced from a flight recorder or a dedicated health monitoring system. This allows for a quick start and highlights what gaps in data flow need to be addressed."

Matthew Emery is the digital maintenance solutions product manager at Honeywell Connected Aerospace. He reports that while the company's connective maintenance offering has ended and the analytics licensed to Lufthansa Technik for deployment in the AVIATAR platform, Honeywell still has many other digital maintenance offerings, such as PTMD (Predictive Trend Monitoring and Diagnostics), Engine Health Monitoring and Maintenance Advisor.

Data driven

For Emery, the key elements of a predictive maintenance programme are led by "good timely data, accurate and proven analytics and clear insights/ recommendations".

There are, of course, many parameters monitored on an aircraft. Getting the most important intelligence for operations may mean prioritising some, probably depending on how mission-critical a system is.

"Yes," says Emery, "When developing our algorithms, we target the systems and components that have the largest impact – namely those which can cause AOG, delays, cancellations, performance penalties and are difficult to troubleshoot on airline operations such as auxiliary power units (APUs), air-conditioning,

pneumatics and landing gear."

AJW's Miret Mora notes how the aviation world has seen a surge in data with the rise of e-enabled aircraft. "For instance, a Boeing 787 with Rolls-Royce engines can generate 500GB of data per flight, and an Airbus A350's 50,000 onboard sensors amass 2.5 terabytes of data daily. This data influx presents a major challenge – distinguishing critical information from noise," he states.

"Aviation experts, whether in airline operations or product development, grapple with the need to prioritise data parameters, a crucial aspect of effective PdM in aviation. Leading players like Airbus and Boeing recognise that successful PdM adoption requires collaboration across four key segments: engineering analytics, data management, decision-making processes, and software development," Miret Mora elaborates. "They have refined their data analytics capabilities and partnered with non-aviation companies to seamlessly integrate PdM software such as IBM, Microsoft, and so on.

"The spectrum of data, however, varies by aircraft generation. Older designs like the A320ceo have limited sensor coverage, mainly for flight controls, hindering comprehensive health monitoring. This emphasises the importance of data availability from these sensors for effective PdM," the AJW exec adds.

"Furthermore, PdM algorithms often focus on detecting specific component failure modes rather than addressing all potential failures of a component. For instance, an algorithm might target electrical malfunctions in a component such as the pressure regulator valve (PRV), leaving other failure modes unattended. The effectiveness of PdM depends on the sensors' ability to measure relevant parameters.

"To illustrate, an analysis of the PRV electrical failure algorithm found it identified only 20.9% of annual removals, with traditional maintenance practices accounting for the remaining 79.1%. Transitioning fully to PdM for complex components like avionics necessitates developing multiple algorithms, constrained by sensor coverage and complexity," Miret Mora remarks.

Collins' Babcock acknowledges that many parameters monitored on aircraft trigger events such as fault codes or ACMS messages but says only a small number of those parameters are recorded and transmitted to the ground.

"When it comes to predictive maintenance, airlines are learning that the standard data supplied in the Arinc 717 FOQA data feed is limited, and more data is needed to develop analytics for complex systems like pneumatics, air management, hydraulics, and electrical power. Many are considering aircraft interface devices that enable the airline to connect to many additional Arinc 429 connections and record these parameters on that device," he adds.

"Today's modern aircraft have millions of parameters flowing through their networks. As predictive maintenance becomes more of a common industry-adopted tool, this will push the industry to record more data, as close to native rates as possible, to enable deeper analytics to be developed," Babcock predicts.

According to GE's Schoonveld, modern systems can capture all, or nearly all, the traffic on aircraft networks. "It's critical to be able to prioritise the data that is most valuable, and often that comes down to the components and systems that are

> *"Predictive maintenance is a cultural shift, which requires changing parts or performing maintenance before something breaks"*
>
> Steve Schoonveld, director of product management, Connected Aircraft at GE Aerospace

causing the most disruption," he explains. "We collaborate with our customers to identify the top issues and then systematically address those by focusing on obtaining and curating the needed data. Leading health monitoring systems also allow for rapid updates to change what data is collected so they can grow with an operation over time.

"The depth of the diagnostics is a function of the data collected. Frequently, individual components can be diagnosed. In cases where the data doesn't support isolation to a line replaceable unit (LRU), we often find that the set of possible causes or areas to investigate can be reduced, allowing the aircraft mechanic to target their efforts and quickly return the aircraft to service," Schoonveld elaborates.

Perfect timing

Successful predictive maintenance demands that parts are in place at precisely the right time. Different ideas exist on how this is best achieved and what hurdles must be overcome.

"Ordering and moving parts based on predictive maintenance is a cultural shift," Schoonveld observes. "Ultimately, people need to be able to trust that they are doing the right thing and be incentivised to order parts before a failure. Predictive maintenance is a collaborative effort, and successful programmes engage cross-functional teams at the start to ignite that cultural shift.

"Secondly, integrating aircraft data with MRO systems is another big leap forward in productivity. Remaining useful life forecasts and predicted failures complement traditional demand planning techniques to ensure the right parts

are where you need them," he states.

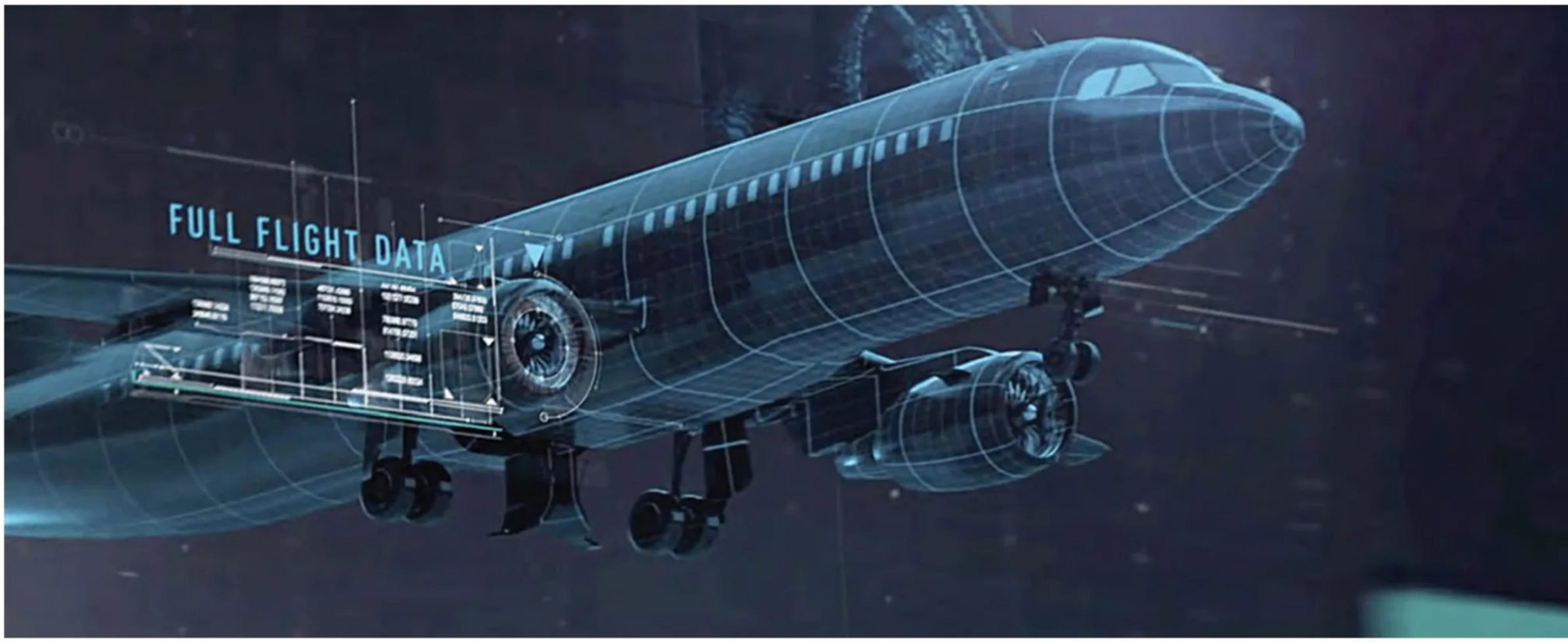
While AJW's Miret Mora agrees that predictive maintenance offers the advantage of precise parts planning, he believes it poses challenges that must be addressed. "While PdM enhances planning by anticipating potential component removals, it may sometimes increase removal rates. This can necessitate higher inventory levels to meet the demand for replacements," he elucidates. "On one hand, PdM pre-emptively schedules removals to prevent AOG situations. On the other hand, it may require more significant investments in inventory due to increased removals.

"This balance presents a significant industry challenge. While PdM helps airlines avert AOG events, it can lead to more removals in certain algorithms. Illustrated in the graph for a component in ATA 32, the combination of traditional removals (US) and PdM removals (PdM) results in a higher number of removals, thus raising repair costs. The price has increased by over 250%, with a 118% increase in removals. This is an extreme case to give a perspective of some algorithms," Miret Mora notes. "Achieving a harmonious balance between these conflicting aspects requires industry-wide collaboration and solutions to optimise overall maintenance strategies."

Collins' Babcock looks at the parts availability challenge from first principles. "Parts rarely fail overnight. There is typically a signal or trend of declining performance weeks to months before the failure," he confirms. "Our data science team is focused on identifying these scenarios and providing an average lead time to failure of 30 days. This ensures the airline has enough time to react and plan repairs while avoiding removing the component before a significant portion of its RUL (remaining useful life) has been consumed.

"As soon as an alert is triggered in Ascentia [Collins' analytics solution], the airline can begin planning for repairs. This means moving the right parts and materials to meet the aircraft and scheduling the repair task. The operator can identify when they are underutilising their manpower and schedule the repair," he adds, noting that without a PdM programme, the part might fail and could result in excess costs for AOG material allocation.

"Sometimes, a maintenance station runs out of components or tools because of a prior, inaccurate fault diagnosis. A deferred item provides an opportunity to re-evaluate the solution required for the fix. With a PHM (prognostics and health management) solution, troubleshooting effectiveness significantly improves, as it precisely identifies the necessary components for the repair," Babcock remarks.



OPPOSITE TOP:
Embraer is another "early adopter" of predictive maintenance, with its AHEAD (Aircraft Health Analysis and Diagnosis) system, to which Scoot was recently signed
Embraer

OPPOSITE BOTTOM:
Collins Aerospace's sister company within RTX, Pratt & Whitney, offers engine health management services
Collins Aerospace

Honeywell's Emery concurs that PdM should give notification before component failure, allowing the operator time to plan and order spares. "Whereas diagnostic maintenance analytics improve troubleshooting of a failed component, in this case, you would need to have a spare at the point of failure. For improving spares availability, you would need insights on your spares pool and usage," he comments.

Adopting PdM can come down to how much of an investment is required and the return time on that investment. "It depends on how you intend to use the system, the digital/data skills of your engineers and their trust in the data," Emery posits. "If it becomes a tool for your MOC/MCC (Management Of Change/Maintenance Control Centre), the upfront investment in training will be higher, but the investment should be lower over time. However, if you set up a team that is purely focused on the digital side, then the investment is likely to be higher over a period of time but smaller on the upfront training."

Steve Schoonveld states that with the infrastructure in place to obtain aircraft data, the ROI on predictive maintenance projects can be as little as 12 months. "The rotorcraft industry has used analytics for decades. On rotorcraft applications, health monitoring systems can deliver a 9% increase in aircraft availability and savings of over $100k/year per aircraft. Customers tell us that for every $1 put into health monitoring, they get $2 back.

"Military and civil fixed-wing operators are looking to gain similar results and are accelerating their use of aircraft data to improve aircraft availability and reliability. Even on legacy platforms, starting a PdM programme using flight recorder data can provide significant improvements," Schoonveld states.

Seth Babcock says that people often think there is a significant barrier to entry to PdM because of the procurement and installation of an Aircraft Interface Device (AID). "With a 30-day predictive lead time, though, the operator can proactively download their data weekly and still have time to prevent a maintenance event. Operators can start with this approach to keep costs low and build the justification to automate the process through an AID as they see successes with their programme.

"Another common barrier is the requirement for a dedicated team to monitor the alerts generated by a PHM system and translate them into maintenance actions. However, as part of our Ascentia solution, Collins Aerospace now has a dedicated team to monitor alerts," Babcock reports.

> *"Presently, aviation regulations lack a defined PdM structure, creating a significant barrier to its acceptance"*
> David Miret Mora, Technical director, AJW Group

Future outlook

Beyond ROI for companies, AJW Group's David Miret Mora is concerned with how much the industry adopts PdM. "It varies significantly among different stakeholders, reflecting diverse levels of technological readiness and strategic approaches. In this context, one can divide industry stakeholders' level of commitment to PdM into five categories," he comments.

"Innovators are the tech enthusiasts, represented by OAMs (Offerings in the After Market), leading PdM technology development. For instance, Airbus's Skywise product is an industry leader, reflecting substantial investments in advancing maintenance practices.

"Moving to early adopters, these are our visionaries – major airlines benefitting from PdM, recognising its potential ROI, notably in reducing EU261 compensation costs," Miret Mora emphasises. "Some develop their PdM solutions, positioning as competitors to established leaders, such as Prognos (by Air France Industries KLM Engineering & Maintenance) and Aviatar (by Lufthansa Technik).

"Small airlines form the pragmatists, appreciating PdM's benefits but carefully assessing ROI against their operational dynamics. They might prioritise cost-saving measures like Soft-Time or reduced Visual Check Intervals," he continues. "Suppliers and AMOs (Authorised Maintenance Organisations) under Part 145 fall into the Late Majority and are the conservatives who have yet to develop robust PdM software or a clear adoption strategy, trailing behind OAMs and OEMs.

"Finally, regulators are the laggards, the industry sceptics, facing challenges integrating PdM into aviation, given their reliance on the MSG logic framework. They must decide whether to invest in aligning with PdM practices or maintain the current regulatory status quo.

"Achieving widespread adoption of PdM across all industry players requires addressing these challenges and fostering collaboration among stakeholders," Miret Mora declares.

The AJW Group technical director believes that PdM is poised to reshape aviation maintenance. "As technology rapidly advances, with innovations like composite materials, IoT (Internet of Things), AI (Artificial Intelligence), and ML (Machine Learning), the aviation industry must formalise its approach for the next maintenance era. Successful adoption hinges on technology acceptance, robust governance, and data quality – an essential step toward achieving the potential of predictive maintenance in aviation," Miret Mora concludes. **AI**

The RAF's training system has been the topic of countless news headlines in recent years, leaving trainees on hold for months, awaiting a pilot flying slot. Added to this have been unfortunate cost-cutting exercises. **Jon Lake** looks through the chaos to see if there's a solution

LESSONS
to be learnt

A pair of Hawk T.Mk 2s of No.IV Squadron, the older of the two Hawk-equipped shadow squadrons at RAF Valley. Hawk engine issues have severely impacted RAF pilot training
Royal Air Force

Some 44 years ago, when, as a young Cadet Pilot on the University of London Air Squadron, I flew my first solo in Bulldog T.Mk 1 XX553, I was very aware that I was benefiting from what the World recognised as a 'gold standard' flying training organisation. No expense had been spared at the 'cutting edge'. The Bulldog was more of an aeroplane than it perhaps needed to be – well-engineered, tough, rugged, fully aerobatic and with 200hp on tap.

My instructors were all first-rate, highly motivated, and from various frontline backgrounds. The 'boss', Wing Commander Al Gross, was a distinguished Lightning pilot, as was the CFI, 'Jock' Byrne, while my instructor, Don Merriman, was a former Canberra pilot and a former CO of the Canberra

OCU. Sitting above them, the 'Trappers' of the Central Flying School (CFS) demanded standards that even the best instructors were stretched to meet. Competition among RAF applicants and student pilots was fierce, and the RAF could afford to be very demanding, as it attracted the very highest of high fliers.

And it was just as fussy when it came to its training aircraft, with the A&AEE (Aeroplane and Armament Experimental Establishment) and CFS between them ensuring that the RAF's student pilots would be trained on the very best aircraft available for a particular training phase.

The system was generously resourced, and the 'chop rate' was fierce. Even on a University Air Squadron, there was a generous allocation of flying hours, and those of my squadron mates who joined the RAF after their studies found themselves well prepared for the Jet Provost and Hawk, and they were on the frontline within two or three years, still young and sharp.

Things are very different today. The reputation of the RAF's flying training system has been tarnished. It now has to work much harder to attract the 'best of the best' and struggles to retain them. Flying hours have been pared back, and most of its training aircraft were selected by the companies and consortia who now run the system, with commercial pressures ensuring that the aircraft used are not necessarily the best available but, more often, the cheapest types capable of fulfilling the role, and of generating the best return for the provider.

Thus, while the World's leading air arms use the Pilatus PC-21 as their primary trainer, the RAF has the Beechcraft T-6 Texan T.Mk 1 – selected not by the RAF but by training provider Ascent. And while the RAF's instructors were once mainly frontline pilots undertaking an instructional tour, able to inspire their students and pass on the 'ethos' of the service, a surprising (and growing) number of instructors today are civilians who have never flown an operational type. These factors alone mean that the RAF's once-vaunted training system is viewed by many as being more gilt than gold. The situation is much graver than that, and many believe that the entire system is damaged, if not completely broken – and that worse is to come.

By the mid-1990s, Private Finance Initiatives (PFIs) had become a significant vehicle for funding major Ministry of Defence equipment projects. The MoD began looking at using a PFI-based solution for flying training up to, but not including, the operational conversion unit (OCU) element of training, which is the final phase of the flying training pipeline but is not part of the UK Military Flying Training System (UKMFTS).

The first major aircrew training PFI emerged in October 1996, when a 15-year contract was placed with FBS (a consortium formed by Flight Refuelling Aviation, Bristows Helicopters Ltd and Serco) for helicopter pilot and aircrew training. This contract covered engineering and supply services already in place and the 26 Eurocopter Squirrel HT provision Mk 1 and nine Griffin HT.Mk 1 (Bell 412EP) helicopters for the Defence Helicopter Flying School at RAF Shawbury and 40% of the required instructors.

Defence Helicopter Flying School (DHFS) was formed on April 1, 1997, and replaced the former RAF 2 Flight Training School (FTS) at Shawbury, the Royal Navy's No.705 Squadron at Culdrose and the Army Air Corps Centre at Middle Wallop – all operating the Gazelle, and in the case of 2 FTS, the Westland Wessex.

The Squirrels served with 660 Squadron, providing basic helicopter pilot training to pilots from all three Services, with 705 Squadron then providing more advanced instruction preparatory to moving on to the Griffin with 60 Squadron for twin-engined helicopter training. The DHFS also oversaw the Search and Rescue Training Unit (SARTU) at Valley, using the Griffin HT.Mk 1 and a flight at Middle Wallop with 12 Squirrel HT.Mk 2s, which featured NVG-compatible cockpits and an underslung-load hook.

Another tentative toe was dipped into the water when Bombardier Aerospace was given a PFI contract in July 1998 to replace Bulldog aircraft with the Grob Tutor for use by the University Air Squadrons and air cadets from 1999.

Cost cutting chaos

The Defence Costs Study recommended that multi-engine pilot training should also be civilianised, and there were expectations that similar PFI contracts would be let when Tucano and Hawk aircraft were replaced in the primary and

advanced pilot training roles.

The Ministry of Defence procured several Beechcraft King Air aircraft in 2003. Cobham Aviation Services operated four King Air 350CER aircraft as the Avenger T.MK 1 for the training of rear crew for the Royal Navy (serving with 750 Squadron at RNAS Culdrose). Serco eventually operated eight more King Air 200s and three 200GTs to train multi-engined pilots and weapons systems operator (WSOp) aircrew with 45 Squadron at RAF Cranwell.

In December 2002, the government allocated £39m for assessment of the proposed UKMFTS, for which four consortia would eventually bid, consisting of BAE Systems (BAES), Serco and Bombardier; Boeing and Thales; Kellogg Brown & Root, EG&G and Lear Siegler; and Rolls-Royce, Lockheed Martin and the VT Group. Proposals had to include the provision of new aircraft and their financing, simulators, and specific training infrastructure and facilities.

The intent was to bring all aircrew training (from classroom to cockpit) under a single provider, unifying and consolidating all phases of aircrew training across the three services, leveraging new efficiencies, reducing delays and modernising equipment in the process.

CLOCKWISE FROM ABOVE:
Fg Off James Bell became the 100th Elementary Flying Training (EFT) student to graduate from No.57 squadron since it became part of the MFTS system in 2019 Royal Air Force/Gordon Elias

The H135 (Juno HT.Mk 1) serves with the DHFS at RAF Shawbury, where the first trainee pilot flew the aircraft for the first time on April 25, 2018 Royal Air Force

A Royal Navy trainee observer hard at work in an Avenger T.Mk 1 – a King Air 350 variant used as a 'flying classroom' for training 'rear crew' members Royal Navy

Under the over-arching MFTS contract, the MOD would determine training output requirements and standards. It would provide certain key elements, including airfields, some instructors, and fuel. At the same time, the provider would design and deliver the overall training system, including aircraft platforms, simulators, ground-based training aids, and a training management information system. Provision of aircraft included maintaining and supporting them, and supplying some of the instructors.

BAE Systems pulled out of the bidding in April 2004, citing a conflict of interest as it supplied the Hawk Advanced Jet Trainers (Hawk 128s, later designated Hawk T.Mk 2) for the fast-jet element of the training programme.

The MFTS contract was awarded to the Ascent consortium (which included the VT Group – later acquired by Babcock in March 2010 and Lockheed Martin) in late 2006. The 25-year PFI contract was valued at £6 billion and sought to outsource the training of military pilots and other aircrew from all three UK armed forces to the private sector, and was intended to be fully operational by 2012. In the event, the new training system was rolled out in stages.

The Advanced Jet Trainer element of the UKMFTS programme was initially expected to be provided via a leasing deal under a private finance initiative (PFI) rather than buying an aircraft outright. The original Hawk T.Mk 1 was felt to be inadequate to train pilots for the Typhoon and future Joint Combat Aircraft (F-35B), and there was perceived to be a need for an aircraft with a glass cockpit, modern avionics, sensor simulation and weapons emulation, with a flexible and upgradeable mission system.

BAE Systems was unenthusiastic about bearing the cost of developing and building the new Hawk T.Mk 2 aircraft and then having to wait for lease payments. The Treasury judged its first PFI proposal (submitted in March 2003) unaffordable.

Subsequent calls for a full-scale competition against the Alenia M-346 and the KAI T-50 Golden Eagle were eventually rejected in favour of a direct purchase of the Hawk, with the number required finally being set at 28.

The Ministry of Defence awarded a contract to BAE Systems to develop the Hawk Mk.128 on December 22, 2004, and in October 2006, signed a £450 million contract to produce 28 Hawk 128s. The new Hawk variant flew from

BAE Systems' Warton Aerodrome on July 27, 2005.

The RAF began receiving its first Hawk T2s in 2009, initially maintaining a pool of four to six aircraft at Valley for instructor training. The initial aircraft were in an 'OC0' standard, lacking the embedded simulation capabilities of the final 'OC2' standard. Student pilot training on the Hawk T.Mk 2 began in April 2012.

Though the aircraft were purchased directly, they were fitted into the overall MFTS construct, under which the required infrastructure and simulators were purchased.

Teamwork options

At the other end of the training pipeline, the Ascent consortium running the MFTS programme re-launched a competition for a contractor to supply and support fixed-wing elementary training aircraft at the close of 2012 after a delay stemming from the UK's strategic defence and security review.

A BAE Systems, Babcock, Gama and Pilatus consortium offered the Grob 115E Tutor for elementary training, the Pilatus PC-21 for basic flying training, and the Cessna Citation Mustang for multi-engine training. A consortium of EADS Cassidian, CAE and Cobham offered the Grob G120TP for elementary training and the Beechcraft T-6C for basic flying training. Finally, the Affinity Flight Training Systems consortium (Elbit Systems and KBR) based its proposal on the Grob G120TP for elementary training, the Beechcraft T-6C for basic flying training and the Embraer Phenom 100 for multi-engine training.

Ascent awarded Elbit Systems and KBR a contract for 23 Grob G 120TPs, known as the Prefect T.Mk 1 in RAF service, and these entered service in January 2018, operating from RAF Barkston Heath and RAF Cranwell.

The RAF-assigned Beechcraft King Air aircraft were retired between 2014 and 2018, giving way to five Embraer Phenom 100s. However, 750 Squadron continued to operate four commercially owned but military-registered King Air aircraft, employing a mixture of military and civilian personnel to train Fleet Air Arm observers, Royal Air Force Mission Aircrew Officers and Non-commissioned Mission Aircrew.

Basic training was the final part of the training pipeline to move from RAF control to the MFTS Partnership between the MOD and Ascent (the joint venture between Babcock International and Lockheed Martin).

Thus, the first of ten Beechcraft T-6C Texan T.Mk 1s made its first official flight at RAF Valley on Anglesey on February 22, 2019, while the fleet of about 30 remaining Shorts Tucanos at Linton-on-Ouse, North Yorkshire, graduated their final course of student pilots on November 1, 2019, with further Basic Fast Jet Training conducted

on the Texan at Valley.

Subsequently, on November 8, 2021, Affinity Flying Training Services announced that it had received a £65m contract from the UK MOD for the operation of four additional Beechcraft T-6C Texan IIs by the UK MFTS programme. These aircraft were delivered to Valley on October 30, 2020, to uplift flying hours.

Though helicopter training had been operating on a contractor's basis since 1997, it had 'sat' outside the MFTS construct, and the FB Heliservices (a joint venture between Cobham and Bristow Helicopters) operation was granted a four-year contract extension in 2012.

During this period, Ascent sought new bids from AgustaWestland and Alphar (a consortium formed by Eurocopter, FB Heliservices and CAE) to run the DHFS for a ten-year interim period among the six companies invited to bid on the new Rotary Wing Training Programme.

In 2016, Ascent Flight Training selected Airbus Helicopters to supply 32 helicopters to train RAF, Fleet Air Arm, Army Air Corps and rotary aircrew out to 2033. The £500m contract included the supply of 29 Airbus H135 (EC135T3) helicopters (named Juno HT.Mk 1 in UK military service) and three H145s (Jupiter HT.Mk 1). These began training student pilots in 2018.

This left the entire DHFS training fleet as twin-engined helicopters, reflecting that all frontline helicopters operated by the UK military were twin-engined, apart from a handful of Army Air Corps Gazelle AH.Mk 1s. The privatisation of the search and rescue (SAR) provision reduced the requirement for a more extensive training helicopter, but although only three H145s were ordered initially, four more were added in 2020. The MOD ordered five additional H135s in February 2022.

With all pre-OCU training now managed under the MFTS 'umbrella' by the MOD's chosen training provider, Ascent Flight Training, some might have expected a significant improvement since a more efficient and effective flying training pipeline had been promised. In the event, we have seen more of a collapse.

By January 2019, it was estimated that it would take a pilot 90 months (seven-and-a-half years) on average between graduating from initial officer training (IOT) at RAF Cranwell and reaching a fast jet OCU – rather than the 28-31 months it was supposed to take. Moreover, 240 RAF student pilots (of 350 across defence) were classed as 'on hold', waiting for their place in the following

OPPOSITE:
One of Valley's new T-6C Texans over the Irish Sea. The T-6C has replaced the Short Tucano in the basic flying training role
Royal Air Force

BELOW:
The main aircraft types used to deliver training under the MFTS construct. The Grob 115 is not shown
Ministry of Defence/Paul Saxby

training phase, compared to 169 pilots in February 2018 and just 17 in June 2016.

By mid-2022, it was revealed that of the 596 personnel in the flying training pipeline from all three services, some 347 were either on a 'hold', awaiting a slot on a training course, or were undergoing "refresher" training after an extended lay-off from flying training. In that year, just 11 pilots went through to a fast jet OCU, though 43 places had been available. On a more positive note, the gap between finishing IOT and starting OCU had reduced slightly to 77 months.

But with IOT taking 24 weeks, and Typhoon conversion taking 14 months to combat ready status (and F-35 conversion slightly longer), it is unlikely that a trainee fast jet pilot will get to the frontline before at least eight years have elapsed, a very significant part of the minimum 12-year engagement, and giving the RAF not much more than a single 'tour' in which to get a return on its investment. The RAF's recruiting website still states that flying training will take 18 months to two years!

Moreover, with RAF pilot numbers coming under pressure from higher-than-anticipated losses of trained aircrew to the airlines and industry, including companies training foreign air forces, the reduced output from MFTS has made the situation critical. In November 2022, the then Secretary of State for Defence, Ben Wallace, said that he had raised the "pilot pipeline" problem with the then Chief of the Air Staff some three years previously but that since then "we have effectively gone backwards", and that "the pilot training pipeline was not where I wanted it to be".

Wallace revealed that at one point in 2022, the UK had more F-35B Lightning II stealth fighter jets than it had pilots to fly them, though, by 2023, he acknowledged that the situation had improved slightly, with 33 Lightning pilots (some of them US and Australian aviators 'on exchange') and 27 F-35Bs. This was still far short of the number required.

Concerns remain about the number of qualified pilots leaving the RAF rather than staying on, which has particularly impacted the service's ability to fill instructor roles. An internal briefing document reportedly said: "The draw is so great from such a small pool we are approaching a critical mass point."

How did we get here?

Force reductions flowing from the 2010 Strategic Defence and Security Review (SDSR) had led to a reduction in the number of pilots being trained from 250 per year in 2010 to 150 in 2012, while rear-crew personnel requirements dropped from 170 to less than 80 over the same period, and MFTS saw its budget being halved. The 22 Group and Ascent had been forced to redesign the MFTS structure, with fewer instructors and aircraft, training fewer students.

The system then had to be ramped up again following the decision to acquire the P-8A Poseidon and to form two new Typhoon squadrons as part of the 2015 Defence Review. This did not provide extra resources for MFTS, which was expected to grow the aircrew training pipeline by leveraging efficiency savings

RIGHT:
The Grob G115 Tutor is used by the Royal Air Force for University Air Squadron (UAS) elementary flying training and air experience flying for the Air Cadet organisation with 15 UASs and 13 AEFs. It is also used by the Fleet Air Arm and the Army Air Corps for flying grading
Royal Air Force

RIGHT:
The turbine-engined Grob 120TP Prefect T.Mk 1 has replaced the Tutor T.Mk 1 in the elementary flying training Role with the RAF College at Cranwell
Royal Air Force

within its existing budget.

Industry claimed that there had been insufficient time and resources to increase capacity to cope with the increase in student numbers. However, many senior service officers felt that this was an excuse, being deployed to cover up the fact that the provider had not resourced the system sufficiently to cope with the fluctuations and surge requirements that should always be expected from a military flying training operation. They concluded that insufficient resilience had been built into the MFTS at its inception.

Resilience and flexibility are required because flying training has traditionally formed an essential element of Britain's defence diplomacy and soft power, and supports defence exports. Large (but unpredictable) numbers of foreign pilots have been and will need to be trained within MFTS. Over the past decade, for example, some 100 Saudi pilots have been trained in the UK, including 25 converting to the Typhoon and 32 Qatari Typhoon pilots.

Many on the industry side responded that such flexibility could have been provided and offered, but the MOD had been unwilling to pay for it! Interestingly, in France, Babcock and Dassault's F-Air 21 contract (formerly known as FOMEDEC) has seen a highly effective and flexible delivery of flying training for fast jet aircrew and one that is sometimes held up as a model solution.

But in the UK, there seems to have been a marked lack of flexibility or even the kind of goodwill that the more naïve might have expected. Some 560 individual helicopter flying training courses were planned between 2018 and 2023, some 86 of which were not taken up due to a reduced requirement for helicopter pilots following the war's end in Afghanistan. The *Daily Express* reported that Ascent said it would not refund the cost of those courses nor use the flying hours to clear the existing backlog.

Instead, the MOD has been forced to devote further resources to solving the problems.

Some improvements will be leveraged by increasing UKMFTS trainee throughput by improving syllabi, course sequencing and training delivery across the UKMFTS flying training pipelines.

Looking at options

However, in the summer of 2018, it was revealed that 22 Group was looking outside the MFTS construct to try to clear the backlog of holding pilots and aircrew. L3 Commercial Training Solutions, based at Bournemouth's Hurn Airport, was given a contract to train 100 RAF multi-engined aircraft pilots over three years, described as a "temporary outsourcing of multi-engine pilot training (MEPT)".

While it was possible to use commercial providers to produce multi-engined military co-pilots who met the input standard for an OCU, finding a means of training fast jet pilots outside MFTS was relatively less straightforward. This was unfortunate as the backlog in pilot training affected the fast jet 'stream' most severely.

Efforts were made to increase the fast jet training capacity of MFTS itself, and a second Hawk T.Mk 2 unit, 25(F) Squadron, was re-formed at RAF

LEFT:
The Embraer Phenom is used for training multi-engined pilots, though some believe that it lacks the demanding handling characteristics they believe is essential for this role
Affinity

LEFT:
Four Avengers are operated by 750 Naval Air Squadron at Royal Naval Air Station Culdrose in Cornwall, under a contract with industry partner Ascent Flight Training. The Avenger is used to train observers for the Navy's maritime helicopter force, instructing them in the management of systems and sensor equipment
Royal Navy

Valley in September 2018. However, without extra aircraft, its impact was relatively small. Arguably more significant was the decision to send some fast jet students to RAF Leeming to train in 100 Squadron's Hawk T1s. This Adversary squadron was felt to have some spare capacity. So, three years after fast jet training on the Hawk T.Mk 1 had officially ended with the disbandment of No.208 Squadron in 2016, a handful of pilots found themselves training on the old 'steam age' cockpit of the Heritage Hawk.

The 100 Squadron had already embraced some training roles alongside its regular 'Red Air' tasking, having taken navigators who had completed the Advanced Fast Jet Dominie Module (AFJDM) with No.55 (Reserve) Squadron and given them 35 flying hours on the Hawk T.Mk 1 to prepare them for a fast jet cockpit environment. This came to an end when training of navigators for the Tornado GR.Mk 4 ended.

The final students to graduate from Advanced Fast Jet Training (AFJT) on the Hawk T.Mk 1 with 100 Squadron finished the final course in September 2021. It began its Operational Conversion to the Typhoon FGR.4 in October, while No.100 Squadron disbanded on March 31 2022.

The timing of 100 Squadron's disbandment was unfortunate, as at much the same time, an engine problem with the Hawk T.Mk 2 exacerbated the MFTS fast jet pilot output problem. The RAF briefly grounded the entire T.Mk 2 fleet as a precaution at the beginning of 2023, but while the aircraft was soon returned to service, the issue continued to limit aircraft availability as Rolls-Royce rectified engines.

The issue will likely negatively impact training capacity for the next two or three years, increasing holding times for fast jet trainees and the backlog.

In October 2022, the MOD confirmed that it was examining its options, including sending some trainee pilots to the US-run Euro-NATO Joint Jet Pilot Training (ENJJPT) Program at Sheppard Air Force Base, Texas. The throughput of RAF pilots at Sheppard is reportedly planned to total 14 students over four years. During an evidence session before the House of Commons Defence Select Committee in May 2023, incoming Chief of the Air Staff Air Chief Marshal Sir Richard Knighton revealed that around 27 fast jet pilot trainees would train overseas before returning to the UK for their OCU training.

The remainder of the 'overseas' trainees are expected to train in Italy under the terms of a three-year agreement with the International Flight Training School at Decimomannu air base in Sardinia, where the first cohort of RAF trainees were expected to begin training in July 2023.

On October 12, 2023, it was announced that UKMFTS would also join the NATO Flying Training Europe (NFTE) partnership, joining Belgium, Czechia, Greece, Hungary, Italy, Montenegro, North Macedonia, Romania, Spain, and Turkey. Germany joined the programme at the same time. The NFTE was inspired by and is loosely modelled on the NATO Flight Training in Canada (NFTC) programme, which has trained Canadian and Allied pilots since 2000.

Initially launched in 2020 by 11 partner air forces, the NATO Flying Training Europe (NFTE) partnership designated the International Flight Training School (IFTS) at Decimomannu and the Flight Training Center (CLV) at Pardubice in the Czech Republic as the initial two NFTE Training Campuses. The NFTE initiative is expected to see the gradual build-up of a network of European training campuses covering different types of aircrew training, providing its participants with access to a much more comprehensive range of training opportunities than they could sustain independently – and at a fraction of the cost. The NFTE campuses will provide aircrew trainees with cutting-edge training, including virtual reality technology and simulation.

This year, student flying began, and three additional campuses were added – the 120th Flying Training Wing at Kalamata in Greece, Kecskemét Air Base in Hungary, and the Pilot Training Centre at Skopje in North Macedonia.

Membership of this 12-nation partnership promises to allow MFTS to

share flying training facilities with some of the UK's closest NATO partners. The scheme is intended to train fast jet, helicopter and transport pilots. Initially, UAV pilot training would not be offered under the NFTE project. Still, because of the high levels of interest shown by several Allies, UAV pilot training is included in the initiative.

Beyond MFTS

A small number of fast jet pilots are again being trained outside the scope of MFTS. When Qatar ordered 24 Typhoons from BAE Systems in September 2017, the £6 billion contract, which included a long-term fast jet training solution, with six (later nine) Hawk Mk 167s to be operated by a joint Qatar Emiri Air Force/RAF unit (No.11 Squadron, QEAF) at RAF Leeming. In return for providing facilities at Leeming, the RAF was allocated flying hours to allow for the training of a small number of RAF trainees per year.

The Qatari Hawk 167 resembles the RAF Hawk T.Mk 2 (Mk128). The QEAF requirement was to broadly follow the established RAF CFS pilot training syllabus and to be similar to that flown by 4 Flying Training School at RAF Valley, with a 50-hour advanced flying training course and a 45-hour tactical weapons training phase. The first two courses conducted by the squadron were 'all Qatari', but in its second year of operation, there was scope for RAF pilots to be trained, and in the most recent course (which commenced in August 2023), two of the six students were RAF pilots.

There have been reassuring statements that the various additional training measures will ensure that UK defence will continue to have sufficient trained pilots to meet its operational requirements. It will also deliver "value for money for the UK taxpayer". But behind such bluster, it is clear that problems remain. The RAF commissioned a £480,000 review into the aircrew shortage from the Boston Consulting Group, seeking potential solutions and gauging support for different options. The brief for this review stated that the RAF "urgently needs to increase the number of trained aircrew to match operational demands".

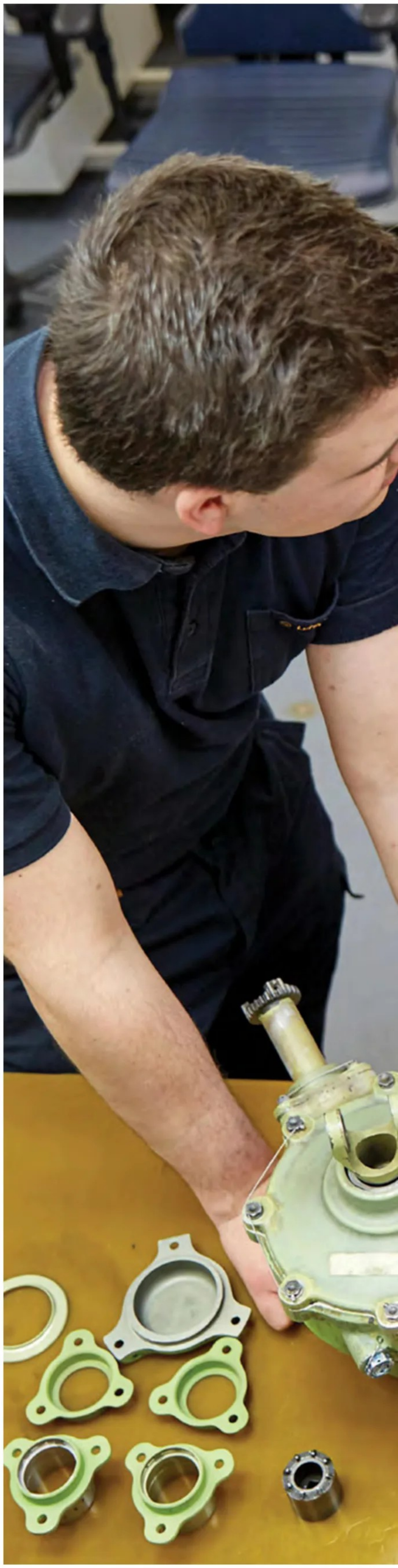
The enormity of the failure to produce sufficient pilots and to do so in a reasonable timescale has tended to distract from other problems and criticisms. We have already covered the doubts about whether a commercially-run, partly civilian-manned training operation can adequately pass on a military ethos to its students. However, there are other concerns, too. Some believe that the use of civilian, commercial aircraft platforms is sub-optimal. That aircraft like the H135 and H145 are unlikely to teach applied military piloting skills in the way that the Gazelle and Wessex could or that the Embraer Phenom is challenging enough (especially in terms of its size, weight, and relatively benign asymmetric handling characteristics) to provide adequate preparation for aircraft like the A400M Atlas.

And despite the efficiencies claimed for MFTS, military pilot training remains eye-wateringly expensive.

A recent Freedom of Information Act (FOIA) response revealed that in 2022, it cost £5,362,085 to train an RAF fast jet pilot, £1,041,843 for a rotary wing pilot and £953,817 for a multi-engine pilot. It was explained that the fast jet pipeline is longer than the multi-engine and rotary wing pipelines, thereby entailing higher pay and support costs, and with a third phase of training using the Hawk T.Mk 2, which has higher support costs than other training aircraft, and that burns significantly more fuel – estimated as being 6.5 times more than the H145 and 2.75 times more than the Phenom, for example. **AI**

OPPOSITE:
Student pilot training on the Hawk T.Mk 2 began at RAF Valley in April 2012
Royal Air Force

LEFT AND BELOW:
The RAF/QEAF joint Hawk unit, No.11 Squadron, Qatar Emiri Air Force, has started training RAF students alongside the Qatari pilots it was originally established to train. The latest course included four Qatari and two RAF students
Royal Air Force



Lufthansa Technik trainees being led through component maintenance
Lufthansa Technical Training

The airline industry will need large numbers of maintenance personnel in the years ahead. **Bernie Baldwin** reports on career pathways candidates can take and the technology used to help meet those targets

Delivering the trained maintainer

Despite setbacks from the COVID-19 pandemic, fallout from conflicts and global economic instability, there is little doubt that the airline industry is continuing to grow considerably. Behind those revenue seat miles/kilometres increases lays the foundation for delivering that growth – aircraft available at every opportunity and, equally important, the people maintaining and operating them.

Keeping aircraft airworthy, no matter how they will be powered in the coming years, will require large numbers of well-trained maintenance personnel. In its global services forecast for 2022-2041, Airbus expects the market to more than double over that period, predicting a need for 640,000 new technicians. In its pilot and technician outlook for 2023-2042, Boeing foresees a demand for 690,000 new technicians.

Against severe competition from other industries, the airline business must show itself to the young to be a rewarding career in every sense. And, arguably, maintenance has an even tougher task in promoting itself above a career as a pilot.

Once convinced of the benefits of working in maintenance, repair and overhaul (MRO), the candidate must find the route to a job that best suits them.

Mark Holloway is director of aviation at the Aviation Institute of Maintenance, which has 14 aviation maintenance schools in 11 states across the US. He is perfectly positioned to describe the main routes to becoming a maintenance engineer/technician and advise on the challenging elements of the process of which a candidate should be aware.

"There are two routes to A&P [Airframe and Powerplant] certification, although the written, oral, and practical testing for FAA certification are identical no matter which route the applicant takes," Holloway

begins. “The first route is to present 18 working months of experience for an A or P to an FAA inspector or 30 months working experience as an A&P. If the FAA agrees, they will sign an 8610-2 form making the applicant eligible to take written and oral and practical testing.

“The challenge for the applicant would be that the student typically does not have experience in all testable subjects, and the FAA may or may not agree that the applicant’s experience meets the required working experience. In addition, the applicant may only be eligible for one of the two ratings [Airframe or Powerplant],” he states. “The second option is to complete an FAA-approved Part 147 programme for Airframe, Powerplant, or Airframe & Powerplant to take the required written, oral, and practical testing required of Mechanic Certification.”

Similarly positioned to outline the ways into the sector is Jonathan Price, chief operating officer (COO) at UK-based Resource Group. “There are several routes via which an individual can become a maintenance engineer/technician: self-funded, while employed as an unlicensed technician; employer-funded study while employed; an apprenticeship or a degree,” he remarks. “Each of these are valid routes to a licence and, importantly, are available to an individual at all stages of their working career, whether they are new to the industry or very experienced.

“Regardless of the chosen route, Part 66 theoretical training is challenging and requires academic ability. For a CAT A licence application, a minimum of one year and maximum of three years practical maintenance experience on operating aircraft is required, with a minimum of two years and maximum of five years needed for CAT B,” Price continues. “The process takes time but is necessary due to the privileges an individual gains on receipt of an aircraft maintenance licence. Not all individuals have ambitions of becoming a licensed engineer, and many work as unlicensed mechanics throughout their career.”

Alongside the courses at seats of learning and independent training organisations are the programmes at major airline-related maintenance companies.

“Lufthansa Technical Training (LTT), a subsidiary of Lufthansa Technik, provides a three-and-a-half year vocational training course in line with the German dual educational system and the EASA Part 66 standards,” reports Michael Paarmann, the company’s head of vocational training. “The theory learned in vocational school can be directly applied in practice at the training company. During this period, the trainees are employed by Lufthansa Technik and have the opportunity to continue their career path after successfully passing the final examinations.

“Trainees need to demonstrate a high level of motivation and willingness for continuous learning, working with precision and paying strong attention to details,” Paarmann notes. “Needless to say, good teamwork and communication skills are imperative. Successful technicians often find the challenges to be a source of pride in their work, knowing that they play a critical role in ensuring air travel safety.”

While Swiss AviationTraining became part of Lufthansa Aviation Training some time ago, SWISS itself continues to train its future licensed aircraft engineers. Head of vocational training at SWISS, Cara Pakszies, says these technicians are introduced to the job through a dual vocational training system common in Switzerland. “In this system, school education at a vocational school and practical training in the company are combined in a three- or four-year apprenticeship,” she explains. “In Switzerland, students can start a vocational apprenticeship after completing their mandatory schooling, typically in the ninth grade.

“SWISS offers two options for aircraft maintenance training. One is the apprenticeship as a polymechanic, and the other is the apprenticeship as an automation technician, both with a focus on aircraft maintenance. During these apprenticeships, future polymechanics will learn the skills and techniques needed to inspect, maintain and repair aircraft and their components. Meanwhile, Automation apprentices learn to solve control and automation problems and plan and implement electrical and electronic control systems,” Pakszies adds.

“SWISS carefully selects apprentices who not only demonstrate strong academic performance in mathematics

CLOCKWISE FROM ABOVE:
Hand skills are essential, so Lufthansa Technical Training ensures that trainees receive sufficient instruction
Lufthansa Technical Training

Learning door systems at Lufthansa Technical Training
Lufthansa Technical Training

Trainees practice with hand tools under the guidance of an instructor
Lufthansa Technical Training

upon completing their mandatory schooling, but also possess proficient manual skills, a genuine passion for technical subjects, a fervent enthusiasm for the English language, a remarkable degree of reliability, a strong sense of responsibility, and the ability to collaborate effectively within a team while performing well under pressure.

"The apprenticeships are divided into the following phases," Pakszies elaborates. "In the first two years, apprentices complete the basic training standardised throughout Switzerland. During this period, they acquire the fundamental skills for their profession and attend module courses for the EASA Cat A licence. In the third and fourth years of their apprenticeship, they focus on aircraft maintenance at SWISS. This involves aircraft-specific curricula and, most importantly, on-the-job training under the supervision and guidance of our training experts. Weekly lessons at the vocational school complement the entire training programme."

Across the manufacturers, aircraft have become increasingly sophisticated in their systems, with much more automation and digital systems. Consequently, maintenance training programmes have had to adapt towards students who are more 'digital natives', with greater familiarity with computer applications. Resource Group's Price confirms that the company has evolved its training methods and incorporated new digital tools to provide learners with a modern training experience. "We recently invested £2.5 million to develop brand-new Part 66 digital courseware, with embedded multimedia and interactive enhancements including worked examples and summative quizzes/tests," he notes.

"The new courseware is perfectly designed for self-study, allowing learners to study towards a Part 66 licence in their own time, at their own pace. Resource Group has also adopted the 'digital classroom' concept, offering Part 66 instructor-led training delivered remotely via online video platforms.

"While the addition of technology benefits learners in many areas of training, there is a balance to be had when it comes to basic training. Our apprenticeship training, in particular, focuses on teaching apprentices the basic, traditional skills which candidates will use and develop throughout their career; therefore, a digital influence here adds less value," Price comments.

Panagiotis Poligenis, head of portfolio and innovation at Lufthansa Technical Training, has indeed observed a change in training programmes. "No question, digital technologies are providing a plethora of opportunities to deliver interactive training that appeals to digital natives. Generation Z and Alpha learners do indeed expect modern training methods and digital methods to support their learning journey," he declares.

"At Lufthansa Technical Training, we have been early adopters of digital technologies since all our trainees are equipped with tablets and have easy access to literature, aircraft maintenance simulations and more through our Learning Management System (LMS). We enhance our training as much as possible with digital technologies and are currently working on immersive technology solutions to improve the training. Nevertheless, practical hands-on training on aircraft, engines and components, plus basic hand skills, are key and not being replaced by digital features. Ultimately, the learning objectives determine the right training methodology," Poligenis reports.

Cara Pakszies confirms that her airline's training courses have seen a shift in the way they are delivered. "At SWISS, we consider ourselves pioneers in training and continually strive to improve our training programmes to meet the changing demands of modern

ABOVE:
On-aircraft teaching at SWISS
SWISS

LEFT:
Learning to test aircraft systems in the classroom
SWISS

technology," she states.

"Like the entire aircraft maintenance process at SWISS, our training has been digitised for several years. On the first day of their apprenticeship, all students receive a tablet to access all relevant training content. This ensures that our future aircraft technicians are well prepared for their careers and have access to the latest teaching methods and resources," Pakszies emphasises.

According to Mark Holloway, at the Aviation Institute of Maintenance, students utilise e-books and devices. "We worked with Fulcrum Laboratories to develop a digital platform utilising artificial intelligence (AI) to assist students with test preparation. While our programmes are not delivered in a distance format, AIM utilises Canvas, Teams, and other online resources to enhance communication with our student body," he reports.

Canvas LMS is a learning management system from Instructure which prides itself on providing "all the functionality you need – none you don't". Mentioned earlier by LTT's Poligenis, these systems are software applications which deliver educational courses and training programmes to students while also aiding back office functions such as administration, documentation, tracking and reporting.

Canvas, Teams and Fulcrum Platform are all new course features introduced recently by AIM, which have improved the quality of training. "Also, the FAA now publishes their FAA Airman Certification Standards, and we have been able to incorporate those into our curriculum," says Holloway.

New course features to improve training quality have also been introduced at LTT. "As stated previously, we are currently working on implementing immersive technologies for our basic engine training and aircraft type training," Poligenis remarks. "For quite a while, we have been successfully using 360° Panoramic Views for our engine and type training, which is very well received by our trainees and provides a number of advantages for the training organisation and the learner."

Resource Group, too, has added new elements to its courses. "We have introduced interactive computer-based training (CBT) and courseware to supplement, and in some cases replace, instructor-led training," report Price.

"Our new, digital Part 66 self-study courseware includes 3D graphics, interactive scenarios and engaging video content, specifically designed to maximise learners' understanding of course concepts, regardless of their preferred learning style," he continues. "The courseware also includes end-of-

module knowledge checks with detailed reports to help learners identify their strengths and weaknesses and timed mock assessments to simulate the Part 66 examination experience.

"Our Part 66 instructor-led modules are also delivered remotely via online video platforms, meaning learners can save on travel and accommodation costs that would otherwise be needed for classroom-based training," Price adds.

While all the digital developments in training courses are undoubtedly helpful, a balance in the training work between the classroom, the workshop and on-aircraft training needs to be maintained. "For the Level 3 CAT A apprenticeship, Resource Group delivers a fully approved programme consisting of ten months of full-time training to produce a safe and competent, work-ready apprentice who can actively contribute to the workforce," declares Price.

"With the programme being fully approved, the training must be 65% practical and 35% theory, meaning the durations for each phase are prescriptive. However, we pull on our years of industry experience to build training programmes that maximise our apprentices' chances of success; this includes carefully planning the order of their learning and including breaks to allow apprentices to decompress between topics. We also have a responsibility to try and satisfy employer requests that we receive regarding the scheduling of a programme," he reports.

Balancing the training is a part of the curriculum at LTT, reports Michael Paarmann. "On one hand, we follow EASA regulations depending on the type of training. On the other hand, however, we do put a strong emphasis on workshop and aircraft practical training," he confirms. "As an EASA Part 147 maintenance training organisation owned by one of the biggest MRO companies, we have the unique opportunity to offer huge possibilities for practical training on components, engines and even aircraft."

According to Holloway, regulation changes have influenced the balancing of training at AIM. "The newest FAA rule no longer requires certified Part 147 schools to gain curriculum approval, mandating specific hours of classroom training," he explains. "As a result, AIM takes every opportunity to engage the student population in a workshop/on-aircraft setting rather than what would have historically been considered 'lecture' time.

"Demonstrations, instructor-led field trips, task-oriented training led by employers, and simulated industry and scenario-based activities often replace what was traditionally 'lecture' time. Safety is always the priority, but AIM strives to build student involvement by

ABOVE:
Resource Group offers training on both fixed- and rotary-wing aircraft
Resource Group

LEFT:
Training on augmented reality (AR) and virtual reality systems (VR) at Lufthansa Technical Training
Lufthansa Technik

increasing workshop and on-aircraft training opportunities when possible," Holloway emphasises. "AIM is seeing increased industry involvement within our campuses, as employers reach out to us to develop partnerships and scholarship opportunities to help build the pipeline of future aircraft mechanics."

New or recently-introduced tools – mechanical, electrical or electronic – are helping to deliver training programmes better across the industry. Resource Group's Price reports that the company has significantly invested in upgrading its audio-visual equipment to enable digital and virtual teaching.

"We have also invested around £65,000 to convert our existing avionics workshop into a third sheet metal workshop at our Cotswold Airport base. This is so that we can increase our training capacity in response to the significant upturn in demand for aviation maintenance apprenticeship training," he notes.

"We are also in the process of replacing our existing hangar lighting with modern LED lighting at a cost of around £8,000. This is to improve luminescence for the whole hangar so that our apprentices can complete their hangar floor tasks in good conditions all year round. The lights are also far more energy efficient," the COO says, introducing an extra element of environmental responsibility.

Holloway recalls that the pandemic greatly impacted Resource Group, as it did with many other businesses. Still, the company used that time to invest in and develop its products to prepare for the post-pandemic boom.

"As people could no longer leave their houses except for essential travel, Resource Group had to quickly find a solution to enable our learners to continue their studies. We began delivering courses remotely via Zoom," he explains. "There was a general unease at first around the effectiveness of remote training and how it would impact learning outcomes compared with traditional face-to-face delivery. After trialling the first few remote courses, we found that students received the same high pass rates.

"Post-pandemic, the demand for remote training grew, and the majority of students opted for Zoom delivery over classroom-based learning. We, therefore, updated our delivery methods, and our Part 66 modular training is now completely digital, with either self-study or instructor-led remote delivery.

"Additionally," Holloway continues, "as an industry-embedded training provider, we are highly influential in working with the UK's Institute for Apprenticeships and Technical Education (IfATE) and the Education and Skills Funding Agency (ESFA) to shape the aviation maintenance apprenticeships of the future. We have also been involved with the industry Trailblazer Group for eight years and have been instrumental in developing existing and future apprenticeship standards.

"Finally, as part of our ongoing strategy to provide deployed apprenticeship solutions for our clients, we have opened several apprentice training facilities at key sites across the UK, including London's Heathrow, Luton and Stansted airports. This initiative was introduced post-pandemic as we anticipated UK airlines and operators would no longer be able to commit to large apprentice accommodation expenses," Holloway reports.

Given the considerable numbers of maintenance personnel needing to be trained in the upcoming years, airlines must feel heartened by the amount of work being carried out to ensure that there will be the appropriate number of people to keep their aircraft in 'revenue-generating mode' as much as possible.
AI

Fulcrum creates leverage for maintenance training

Fulcrum is one of the companies to which the Aviation Institute of Maintenance has turned for technical assistance for very specific reasons. According to Fulcrum, over 90% of learning in an organisation is never applied, resulting in a significant loss of time, resources known as 'scrap learning'. The company states that "Fulcrum Labs was created to solve this scrap learning gap, arming leaders with measurable, actionable data to objectively quantify learning and performance while transforming the way people learn."

Fulcrum says its Adaptive 3.0 MicroLearning platform "harnesses AI, machine learning and data-science-driven predictive analytics to: reduce training times and costs; identify on-the-job performance gaps; verify confidence and skills mastery; identify those at risk of not applying the knowledge; and evaluate the integrity of course content."

Fulcrum's mission is to "turn students into learners and turn learners into confident subject matter masters."

Flight instruc

Flight instructing is an excellent way to build flying hours on a multi-engine aircraft
Michael Doran

ver the next 20 years, Boeing forecasts the global commercial fleet will grow by around 21,000 aircraft, and that the industry will need to find and train 602,000 new pilots. Airbus puts the figure at 585,000, while training specialist CAE narrows that to 284,000 new pilots by 2032.

In its 2023 Aviation Talent Forecast, CAE identifies the general ageing of the workforce as a key driver and that more than 45,000 US pilots, almost 27% of the commercial airline pilot population in the country, will be required to retire in the next ten years. Globally, it puts that retirement number at 99,000, with a further 153,000 new pilots needed for projected growth.

While Airbus, Boeing and CAE have gone to great lengths to produce these forecasts, there is no mention of who will train all these new hires or how many flight instructors need to be attracted into this vital element of the pilot pipeline.

ting

Michael Doran discovers how training companies and flight instructors are gearing up to meet the growing demand for pilots across the commercial sector

BELOW:
Flight instructors are in high demand; for many, it's a very rewarding career
Michael Doran

OPPOSITE:
Flight Instructing involves ground school, flying and time in the simulator
CAE

Granted that instructors are pilots, they may be included in the overall estimates. Still, it is surprising that no mention is made of this group, nor are any numbers quantified as to what aviation's projected growth means to this sector. With pilots already in high demand, *Air International* looks into flight instructing and why it is an attractive option.

A turning point

For aspiring professional pilots, gaining the Commercial Pilot Licence (CPL) can be a turning point in their aviation careers, with their direction often depending on the pathway they have taken to get to that milestone. If they are on an airline cadet program, their next step is usually well laid out, and may start with a stint at a regional carrier as the first rung on the ladder.

For those doing it more independently but wanting to become commercial airline pilots, the next step is to build up their flying hours to meet an airline minimum, ranging from 500 to 1,500 flying hours for a direct entry first officer position. For a CPL pilot fresh out of flight school, that means bridging the gap between the 200 hours they graduate with and the hours they need to fly to get an airline direct entry position.

Other CPL graduates may want to move on to different aviation roles in general aviation, flying freight or smaller passenger transport in rural and regional locations. After spending hours in flight school, there will also be some who quite like the idea of a career as a flight instructor, and others will view it as a stepping stone to build hours on their way to becoming an airline pilot.

Regardless of the end goal, all would-be flight instructors follow the same route, which means more study and training to gain an instructor certificate from the relevant regulator, such as the European Union Aviation Safety Agency (EASA) or the US Federal Aviation Administration (FAA).

The process

The critical point is that flight instructor training is not so much about flying ability, as was assessed in the previous Private Pilot Licence (PPL) or CPL course, but rather, it is about teaching someone else how to fly.

The most vital element of the role, which is enshrined in the EASA regulations, is knowing when a student pilot has the knowledge and decision-making skills to be released to fly solo for the first time, a heavy responsibility for anyone to carry.

With that endpoint in mind, working through the EASA process of gaining a Flight Instructor (FI) certificate is worthwhile, similar to how most other aviation regulators mandate the process, including the FAA. The guiding EASA rule is that a person may only conduct flight instruction in an aircraft they hold a licence for and an instructor certificate appropriate to the instruction given.

The FI course is designed to train a pilot to be an instructor capable of teaching a person to qualify for the issue of a PPL. There are a variety of endorsements for areas such as Multi Crew Co-operation (MCCI), Type Ratings (TRI), Multi-pilot licence (MPLI), Mountain Rating (MRI), Synthetic Training (STI) and so on.

Using EASA as an example, a prospective flight instructor needs to gain a Flight Instructor rating, which involves at least 125 hours of theoretical training and at least 30 hours of flight instruction.

Flight instructor courses are widely available, and academies prefer applicants to hold a CPL. However, the regulations allow a PPL holder to obtain an FI(A) provided they meet equivalent flying experience and theoretical knowledge conditions.

For CPL holders, the prerequisites include receiving at least ten hours of instrument instruction and completing 20 hours of VFR (visual flight rules) cross-country flying on the appropriate aircraft category as pilot in command (PIC).

A PPL holder must have passed the CPL theoretical knowledge exam, completed at least 200 hours of flight time, of which 150 must be PIC, and completed at least 30 hours on a single-engine piston aircraft.

They must also have completed a VFR cross-country flight as PIC, including a flight of at least 540 km (300NM) during which full-stop landings at two different aerodromes must be made.

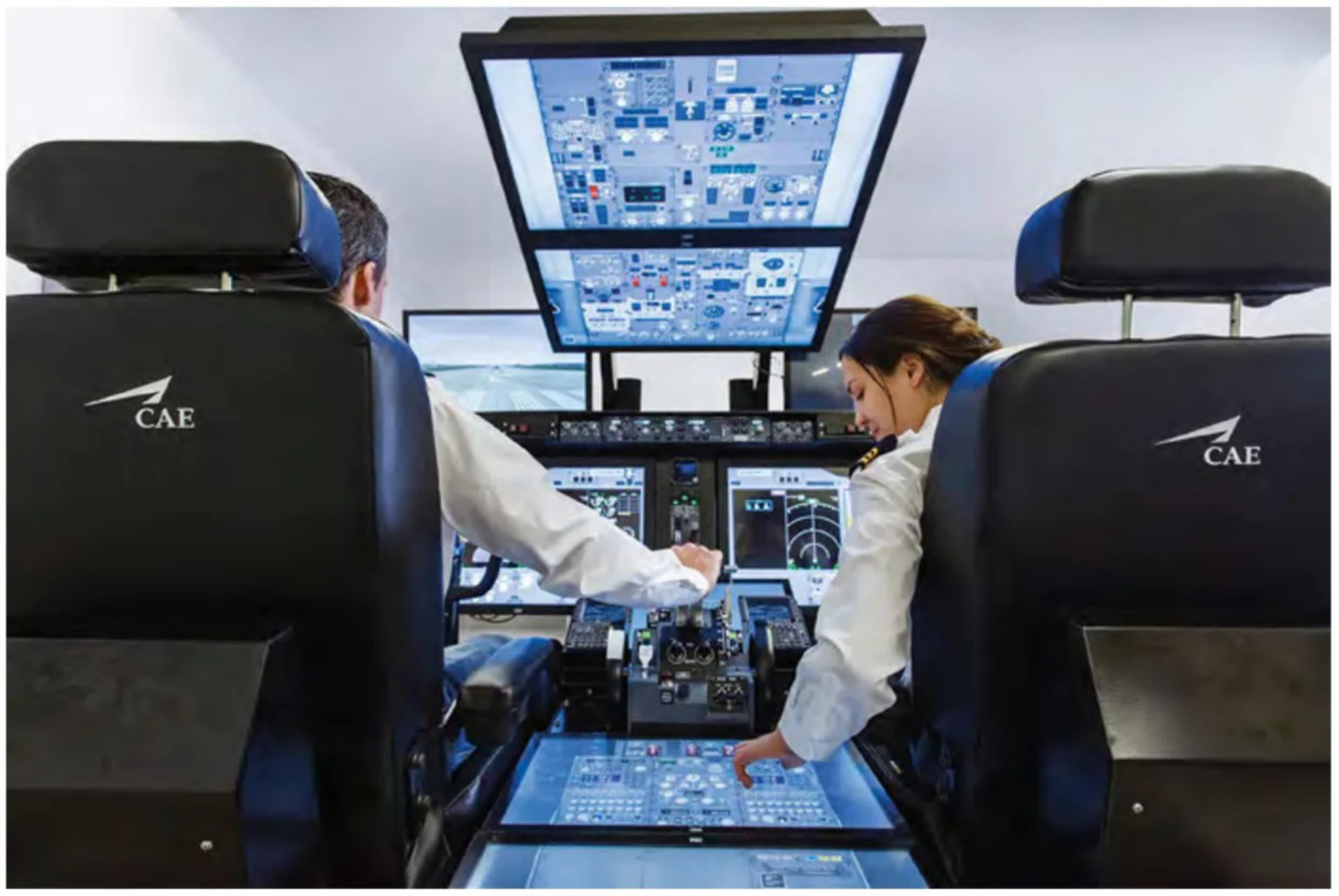
Within the six months preceding the start of FI training, the applicant must pass a specific pre-entry flight test to assess their ability to undertake the course. A flight instructor examiner assesses their performance, and the test is based on the PPL Skill Test.

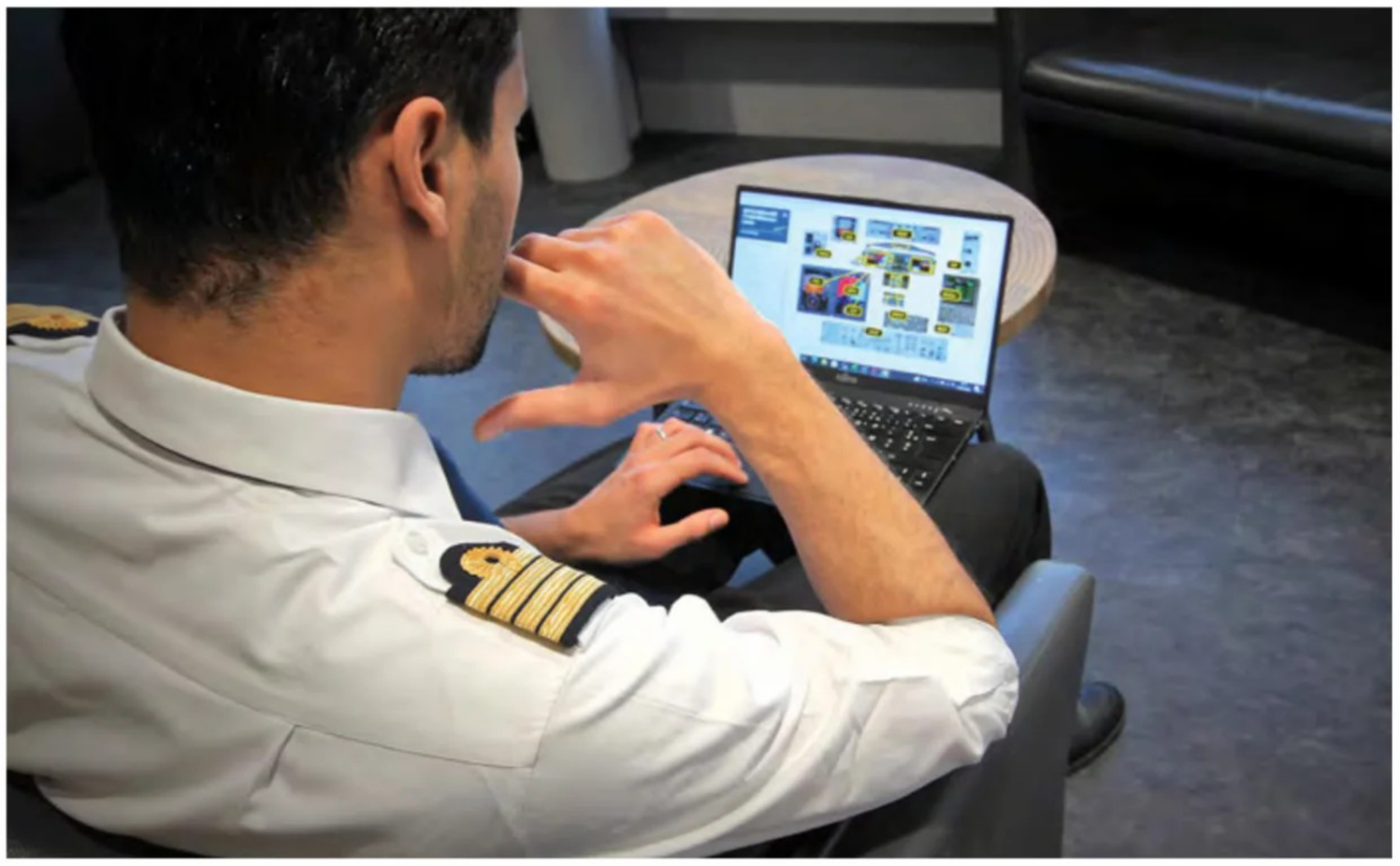
While that flying assessment is a starting point, the objective of an instructor course is to give a licenced pilot the skills and attitudes needed to teach an aspiring pilot how to fly. The first stage of ground school involves:

- ***Learning teaching and evaluation skills, including competency in creating a climate conducive to learning.***
- ***Presenting knowledge.***
- ***Facilitating learning and assessing trainee performance.***

The bulk of the theoretical element is refreshing technical knowledge gained from previous training, studying how physiological and psychophysical factors can affect decision-making, and practical skills, including flight planning, navigation and pre- and post-flight actions. It is all aimed at preparing the instructor to

> *"For a CPL pilot fresh out of flight school, that means bridging the gap between the 200 hours they graduate with and the hours they need to fly to get an airline direct entry position"*





CLOCKWISE FROM TOP:
Students also spend time in flight training devices for their pilot education
CAE

Flight instructing involves ground school, flying and time in the simulator
Simaero

Simaero continues to use the Wisdom remote training platform it developed during the pandemic
Simaero

decide when their students are ready to go solo for the first time.

An exciting approach to ground training is that some providers allow trainees to complete this via online learning or on a virtual platform before arriving at the academy for flight instructor training. In-person or online, there are 125 hours of theoretical training to get through, followed by assessments and exams to assess competence.

EASA mandates at least 30 hours of flight training, of which 25 hours must be dual flight instruction, of which five hours may be conducted in a full flight simulator, flight training device or flight and navigation procedures trainer.

An interesting element of flight instructor training is the principle of giving and giving back as a practical learning methodology. Each flight or manoeuvre is done by an FIC instructor (hand) to teach the student instructor how to teach, and on the following flight, the student teaches the lesson (back) to the FIC instructor.

Once flight training is completed, applicants generally have a final pre-licence flight where they are assessed on their competency to deliver briefings and flight instructions before the test flight. The training organisation can recommend a Flight Test Operator for external testing when completed.

The final FI(A) testing involves a flight with an examiner to cover the techniques and skills learnt during the course, including operating the aircraft from the right-hand seat. Successful completion leads to the FI(R) rating, albeit with restricted privileges while experience is gained.

The EASA regulations say that an FI will have their privileges restricted to conducting flight instruction under the supervision of an FI for the same category of aircraft nominated by the training organisation for this purpose.

While training is done under supervision, the FI does not have the privilege to

authorise student pilots to conduct first solo flights and first solo cross-country flights. These limitations are removed from the FI certificate when the FI completes at least 100 hours of flight instruction and has also supervised at least 25 student solo flights.

Validity period

EASA regulations state that a Flight Instructor FI(A) certificate is valid for three years and can be revalidated by fulfilling any two of the following:

- ***Complete at least 50 hours of flight instruction in the appropriate aircraft category during the certificate's validity period.***
- ***Attend an instructor refresher seminar at an authorised training organisation within the 12 months preceding the expiry of the FI certificate.***
- ***Pass an assessment of competence under FCL.935 within the 12 months preceding the expiry of the FI certificate.***

For each alternative revalidation of an FI(A) certificate, the holder must pass an assessment of competence within the 12 months preceding the expiry of the FI certificate.

If the FI rating has lapsed within 12 months before renewal, the applicant must attend instructor refresher training as FI at an authorised training organisation and pass a competence assessment per EASA FCL.935.

Expensive undertaking

By the time a pilot has gained their CPL, they have probably spent around £100,000, and looking at the UK, the USA and Australia, gaining the flight instructor certificate, including theoretical knowledge, will set them back around £10,000.

Of course, gaining the flight instructor rating does open the door to earning while building up the hours, so it is an investment, even for those on their way to an airline role. If an instructor career looks appealing, it is a necessary prerequisite and is a relatively small addition to the costs incurred in gaining the CPL.

Before flight training became a university degree, logging hours as a flight instructor was a highly favoured way to get to that coveted airline seat and still is today for those taking a more independent route.

The global pandemic saw many pilots leave the profession, either by choice or otherwise. For some, flight instructing is a way back into aviation without the pain and restrictions of returning to an airline.

At a recent aviation conference in Australia, it was illuminating to

Simaero – doing it with wisdom

From its Paris headquarters, Simaero provides flight simulator training to airlines, training organisations and commercial pilots. Its network comprises 30 flight simulators in France, South Africa, and China, providing services to more than 220 civil and military customers.

Simaero has developed a learning management platform, Wisdom, that is accessible 24/7 from anywhere there is an internet connection. The system allows pilots to do theoretical training without attending a training centre and at a pace that suits their schedules.

It was developed in 2020 to provide clients with an efficient solution to continue pilot training during the global pandemic and offer a modern and cost-effective tool to deliver theoretical training.

Wisdom provides the full range of courses, such as Mass and Balance, Limitations, Performances and normal and abnormal standard operations procedures. Specialised modules are also available, including Low Visibility, Upset Recovery and Performance Based Navigation.

Pilots can contact the responsible instructor through the system to seek guidance or feedback, and it also allows real-time monitoring of trainee progress, saving time and reducing expenses for users and their organisations.

Wisdom gives quick and easy access to an intuitive online platform, which is adapted to all internet browsers and IOS and Android platforms, making it available on computers, notebooks, tablets, and smartphones.

In October, Simaero announced plans to open a new training centre in India near Delhi's Indira Gandhi International Airport. It will include a ground school classroom equipped for computer-based training and eight simulator bays offering training using A320, 737 MAX and ATR 72-600 full-flight simulators.

Simaero has flight simulators and training solutions for aircraft types including Airbus A320, A330, A340 and A350; Boeing 737, 757, 767, 777 and 787; ATR 42/72-500/600, ERJ 145, Beech 1900, Dash 8, MD80/82, and Fokker 100 aircraft. The Delhi training centre is planned to be fully operational by the fourth quarter of 2024.

hear a commercial airline pilot say he was deterred from making a switch to instructing by the high rating cost versus the money he would earn.

The pilot was Tony Lucas, a Qantas Check and Training Captain for Airbus A330 and the President of the Australia and International Pilots Association, a guest panellist at the conference.

"I'm an experienced A330 training pilot, but I can't go and train ab initio students because of the cost to me of doing that and the barriers that the civil aviation safety authority put in the way for me to able to transfer those skills easily is very difficult," he said. "It's prohibitive and not worth my time and energy, particularly given the return I'm going to get when I go and instruct a junior pilot, which is not significant."

From researching this article, it seems that most training organisations offering flight instructor training are open to students working for them once the certificate has been gained, meaning the money does not always flow in just one direction.

Urgent demand

The worldwide scramble to recruit pilots has seen many regional pilots recruited by mainline airlines, leading to regional carriers in the US, Europe and Australia having to cut services and ground aircraft. In the US, the Regional Airline Association reported this year that 414 regional jets, 22% of their member-operated aircraft, have already been parked due to the lack of crew.

In Australia, the major regional airline, Regional Express, has seen its pilot numbers decimated by the major domestic airlines poaching experienced pilots, with vital services cut and leaving aircraft on the ground.

Anecdotally, the same thing happens with flight instructors who see the opportunity to fill airline roles much earlier than possible. Regional Express owns two flight academies in Australia, and as well as recruiting pilots for its airline, it is advertising for Flying Instructors for its pilot schools.

The fact that training organisations openly advertise that the students they train to be flight instructors will be able to go on and work as flight instructors indicates the high demand in this field.

Training the trainers

Talking to instructors, it is clear that many love what they do and don't envy their colleagues or former students who are now flying big jets worldwide. They also say that to teach something, you have to understand it, and flight instruction not only builds hours but deepens the instructor's practical expertise.

It also takes us back to those numbers and who will train these 284,000 new pilots we need by 2032. History shows that when the demand for pilots is high, so is the demand for flight instructors, so for anybody who wants a career in aviation without having to be constantly travelling, this could be just what you are looking for. **AI**

Simaero takes flight training for students to a new level
Simaero

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846/23

Embraer's smart move

As airlines search for ever-more economical ways of serving their markets, the 'crossover jet' category of small airliners provides Embraer with a potential route into an expanding portfolio of customers. **Alan Dron** asks if it's living up to the hype

Embraer's newest livery to promote the Profit Hunter E195-E2 is called 'Tech Eagle', in recognition of the growing number of new E2 customers around the world with the motto: "Like an eagle, the E2 flies efficiently and silent"
Embraer

The past 20 years have seen the arrival of a new type of airliner. Smaller than traditional single-aisle types, they were initially classed as 'regional jets' but are increasingly referred to as 'crossover jets'. They span the size gap between regional aircraft (both turboprops and earlier-generation jets) and mainline narrowbody jets such as the Boeing 737 and Airbus A320 families that account for the vast bulk of the world's airliner population.

Brazilian manufacturer Embraer has successfully tapped into this new crossover category with its 'E-Jets', now in their second generation of models. Embraer has one major rival for the crossover jet market: the Airbus A220 (previously known as the Bombardier CSeries), which has also found a ready market, with more than 800 sales to date. (For Embraer sales figures, see sidebar.)

One possible factor that may favour the Brazilian aircraft is that it built up a considerable customer base with its →

The next decade is likely to see members of Embraer's proposed Energia family taking to the skies, operating with zero or close-to-zero emission powerplants Embraer

For some time, Embraer has been looking to launch a new-generation turboprop to accompany its E-Jets. However, this project is – at least temporarily – on ice.

The Brazilian OEM has had plans for a new-generation turboprop in the 70 to 90-seat category for years and has taken these proposals to airlines.

Prospects are promising; the only real competition is ATR's ATR 72-600. The De Havilland Canada Dash 8-400, for many years ATR's main competitor, has had production paused by its owner as it moves its factory from Toronto to a new assembly plant near Calgary.

The Canadian company anticipates bringing a modern version of the Dash 8-400 to market in 2027-28.

Industry observers say that Embraer proposed an aircraft that used a modified E2 fuselage with rear-mounted turboprop engines rather than underwing turbofans. The new aircraft would be aimed at burning 15-20% less fuel per seat than older-technology aircraft, a degree of improvement that would undoubtedly interest airlines wanting to cut fuel burn and emissions. Indeed, at the 2022 Farnborough Air Show, Embraer said it had around 250 letters of intent for the new aircraft.

However, in December 2022, the company announced that development was being paused.

"[Our] market studies and discussions with airlines show strong global demand for an advanced, next-generation turboprop aircraft," Embraer said. "However, the program only works if it meets performance, maintenance, and sustainability targets. Today, the options available from a few suppliers are not yet there concerning all targets."

The main problem is the lack of a suitable new-generation turboprop engine.

GE Aerospace is believed to have decided not to bid an engine for the project. Rolls-Royce and Pratt & Whitney were willing to propose but seemingly could not meet Embraer's targets for fuel burn and other technical aspects.

Industry observers have pointed out that there may be a shrinking window of opportunity for one more conventionally powered turboprop to be launched before new propulsion techniques become the norm. If a conventionally powered turboprop is delayed beyond the end of this decade, it may have too short a service life to be commercially viable.

Meanwhile, Embraer is pressing ahead with smaller aircraft that may use these new propulsion systems, using hydrogen as fuel.

In its Energia project, Embraer originally proposed four aircraft, ranging from nine to 50 seats, with various power options – all-electric, hybrid-electric, hydrogen hydrogen-electric and hydrogen-conventional propulsion.

In December last year, it narrowed down its efforts to two of those designs – 19-seat and 30-seat regional airliners with either hybrid-electric (traditional engines for cruise, with electric for extra power for take-off) or hydrogen-electric (hydrogen tanks and fuel cells mounted in the aft fuselage with electric motors housed in rear-mounted nacelles) power systems. These would potentially enter airline service in the 2030-35 timeframe, slightly later than the proposed new turboprop.

Given the current level of maturity of new propulsion technologies, Embraer believes that the size of aircraft that can be powered by hydrogen or a hybrid powerplant is below 50 seats – probably a 30-seater. For a fully electric aircraft, that perhaps falls to 19 seats.

"If we want to use these new technologies like battery or hydrogen, we need to control the weight of the aircraft and its payload. Otherwise, the weight of batteries will increase exponentially," Galhardo said. "Also, the range has to be at a certain level where we don't demand too much energy from this aircraft. So, that leads us to smaller aircraft. A bigger plane with a small range wouldn't work."

It also probably makes more sense to start small with the new technologies and evolve, step-by-step, into bigger aircraft. However, any new aircraft using these new propulsive technologies must also have enough seats to make the design commercially viable. There has to be a sweet spot.

smaller, previous-generation E135/E145 range, which sold widely and is now increasingly appearing with new owners as second-hand equipment in regions such as Africa.

This may prove profitable as airlines increasingly upgrade their equipment to meet growing market demand, as expanding middle classes in Africa and Asia increasingly use their increasing disposable incomes to take to the air.

In its latest market forecast, released at this year's Paris Air Show in June, Embraer sees global demand over the next 20 years for new airliners in the up-to-150-seat category reaching 11,000 aircraft, with slightly over half – 55% – replacing older aircraft and the remainder coping with growth in the world's markets.

Of those 11,000 machines, the Brazilian OEM calculates that 8,790 will be jets (split 52% to 48% between replacements and growth aircraft), while 2,210 will be turboprops. Embraer believes that smaller

jets will increasingly complement mainline narrowbodies.

Analysts have frequently commented on the relatively slow sales of the E2 series since its first example was delivered to Norwegian regional carrier Widerøe in April 2018.

Daniel Galhardo Gomes, Embraer Commercial Aircraft's strategic marketing director, said a significant reason is that many E1s are still relatively young aircraft, with only ten to 15 years 'on the clock'. Their operators thus see no reason to rush to replace them with the E2s – especially, says Galhardo, as the E1 has shown itself to be very reliable in service.

So, why did Embraer launch the E2 series when its predecessor was still a player in the marketplace?

"There was an opportunity to evolve our E-Jet family," said Galhardo. "We saw the industry moving towards more efficient engines, and we thought 'We can't let the E-Jet fall behind; we have to update it.'

"That engine improvement came earlier than we were expecting, but it was an important evolution we had to follow."

This meant changing the E1's General Electric CF-34 powerplants for Pratt & Whitney PW1900G geared turbofans, including a redesigned high aspect ratio wing and new avionics.

One model of the E1 range remains in production. The E175 was designed to cater to US regional airlines providing feeder services to the country's majors. These regional airlines are bound by tightly drawn 'scope clauses' that limit the size of aircraft they can operate so as not to put at risk the jobs of pilots employed by the majors by allowing their work to be outsourced to the regionals. The pilots' trade unions have been diligent in enforcing these agreements.

Currently, the maximum number of passengers that can be carried by a regional airline aircraft is 76. There is also a limit on a regional plane's certified maximum take-off weight, which cannot exceed 86,000lb.

"Scope clauses are not rational," argues Galhardo. "They are pretty much a negotiation piece between the airlines and the pilots' unions. The pilots' unions are very strong because of the shortage of pilots in the US and because of market dynamics." He believes the time will come when scope clauses will have to evolve because of factors such as the need for more environmentally friendly aircraft and passengers' changing expectations of their flight experience.

That time may not come until the end of the decade, however – hence the pause in developing and producing an E2 variant of the E175.

The E175-E2 would have offered greater capacity to the regional airlines, and the aircraft was designed in the belief that scope clauses would have been amended to allow it to be acquired by the US carriers by the time it came to market. This has not happened, so development has

BOTTOM:
The eye-catching 'Tech Shark' paint scheme was applied to an E190-E2 that appeared at the 2022 Singapore Airshow. The aircraft left Brazil on February 9 and arrived at Singapore's Changi Airport on February 12
Embraer

BELOW:
'Tech Eagle' has the registration PR-ZIQ and is part of Embraer's E195-E2 fleet. The aircraft was built in late 2017
Embraer

CLOCKWISE FROM ABOVE:
Leisure operator TUIfly in Belgium has taken delivery of three E195-E2s specifically to operate holiday flights out of Antwerp Airport, which has a short runway of just 1,510m in length. Despite this, the E195 can reach the Canaries or Turkey with a full load of 136 passengers
Embraer

Large numbers of Embraer E175s serve with US regionals – in these cases, Envoy Air in the colours of American Eagle. The 76-seat E175 is the largest aircraft allowed to be operated by the regionals under the terms of restrictive scope clauses
Embraer

Canadian regional operator Porter is building up a substantial fleet of E2s to service destinations both in Canada and across the border in the US
Embraer

A Portugalia Airlines' E190-E1 in the colours of TAP Express, the Portuguese flag carrier's regional operation, visits an unusually sunny London City Airport
Alan Dron

Production numbers

Embraer has produced more than 1,750 of its E-Jets to date. The breakdown of model numbers delivered is as follows:

E1 Series
E170 191
E175 822*
E190 568
E195 172

*The E175-E1 remains in production, primarily (but not wholly) to cater for US feeder airlines limited by scope clauses. As of October 2023, 740 had been delivered, with an order backlog of 82.

E2 Series
E175 Production delayed to 2027 (est)
E190 34 (18 delivered)
E195 236 (63 delivered)

been delayed until 2027, a decision also influenced by the need to rethink investment plans in light of the financial impact of the pandemic.

Also, said Galhardo, the E175-E1 continues to tick up a steady level of orders from airlines, not just in the US. Nigeria's Air Peace, for example, has recently ordered five.

The aircraft is now the only turbofan in its size class (typically, 76-88 passengers). China has its ARJ21, but this does not have certification by the US or European regulatory authorities, rendering it an insignificant rival outside China or Chinese client states such as Laos.

Galhardo believes E2 sales will accelerate: "We're just now moving into that replacement phase. That perhaps explains the perceived low backlog numbers early in the programme."

"But on the other hand, we also see some airlines changing strategy. For example, KLM [CityHopper] is adding E195-E2s to add capacity in their markets. Also, coming sustainability requirements may speed up some replacements in regions, like Europe."

KLM CityHopper, the Dutch flag carrier's regional subsidiary, operates a mix of E175s, E190s and E195-E2s; the last offers 32 more seats than the E190s' 100.

"We expect to see an increase in the replacement of our first-generation jets in the coming years," said Galhardo, "because of reduced CO2 emissions and the up-gauging of some regional connections."

Almost all the early sales of E2 machines were to airlines that were not operators of the previous E1 aircraft.

KLM is an exception, partly because of the airline's sustainability drive, as is Aerolineas Argentinas, which in October announced an order for 12 E195-E2s, apparently to replace some of its 26 earlier-generation E190-E1s. Embraer understands that two other major European users of the E1, Lufthansa Group and LOT, the Polish national airline, are actively looking at E2s to refresh their inventories.

Embraer does not release production rate figures, but guidance earlier this year said it anticipated producing 65 to 70 E-Jets in 2023. It remains on track to meet this estimate.

"Crossover is a very interesting segment," Galhardo said, as aircraft in this category offer solutions to several airline requirements.

It can 'right-size' capacity on routes previously operated by narrowbodies

in October Embraer Commercial Aviation's CEO, Arjan Meijer, said that discussions were ongoing and "very strategic" with the governments of those countries.

He said: "They involve assembly lines, completion lines; they involve working with local production, getting the Chinese supply chain involved, and of course, we need to work with the aircraft manufacturers there to make that happen as they have a vested interest."

Galhardo agreed there are clear potential benefits from setting up such facilities. "Of course, it's an opportunity to increase our presence in some regions. China, for example. It's important to build relationships with the government and our presence in the country."

Like Meijer, Galhardo said that, in China, India, and Turkey... "We see with that kind of strategy we can improve our capability to deliver more aircraft.

"I think it's an interesting kind of partnership, where we see a win-win situation where we increase our presence in the region and open more possibilities.

"But the stars need to align, so discussing a timeline is difficult."

Embraer has had a presence in China, with a final assembly line in Harbin, in the northeast of the country, producing previous-generation E145s. However, this saw just 45 aircraft rolling off the line in 13 years. Galhardo believes things would be different this time if new co-operation with China materialises.

Previously, the market in China grew very quickly, and how it was organised turned out unsuitable for a 50-seat regional jet like the 145, he explained.

"A 50-seater jet is a very good product to feed hubs and increase frequencies in busy markets, but how the Chinese market evolved was different. They didn't use hubs; it was more point-to-point connections and grew really fast, so the market was more suitable for larger aircraft."

He believes that the Chinese market now realises that a hub-and-spoke network is required to improve the system's efficiency.

One other potential factor in the E2's' favour, Meijer said at the Paris show, is that the E190/195 slots neatly between China's recently introduced ARJ21 regional jet, which typically seats between 78-90 passengers and its even newer C919, →

that have become too large for demand on the sector; conversely, it can provide extra capacity on routes where demand has grown beyond that served by a single narrowbody but where an additional single-aisle mainline aircraft would be too much; it can be the ideal aircraft with which to open and nurture new routes; and its smaller size (and consequently lower costs) make it a useful option when increasing frequencies on sectors.

Those lower costs have been achieved because the E190/195 were purpose-designed, whereas the aircraft that they often replace, the A319 and 737-500 or -700, are 'shrinkages' of the most cost-efficient main member of their families, namely the A320 and the 737-300 and -800.

However, not only economics will define airliners' future success or failure.

Geopolitical trends may increasingly affect the air transport market, with the global economy fragmenting into two competing economic blocs headed by the US and China. This could mean that trade may increasingly be affected by political, not economic, factors.

Perhaps with one eye on this trend, Embraer is currently in talks with the governments of several fast-growing economies (particularly airline economies), namely Turkey, India and China, over the possibility of setting up new production centres there.

These could range from, at their simplest, completion centres for 'green' airframes, with interiors being installed and paint schemes applied, to full-scale final assembly lines, replicating the original in Brazil.

At the European Regions Airline Association annual meeting in Innsbruck

FROM TOP:
Embraer agreed to the sale of 19 E175 jets to Skywest, Inc. for operation in the United Airlines network. The 70-seat aircraft will be delivered in a three-class configuration. Deliveries will begin in late 2024
Embraer

The sales success of the E-Jet range is readily apparent from the special logo on this E195-E2 destined for KLM CityHopper
Embraer

A Lufthansa Group E190-E1 of Italian regional airline Air Dolomiti awaits passengers at Florence's Amerigo Vespucci Airport. Air Dolomiti feeds passengers into Lufthansa's hubs, notably Munich
Alan Dron

which is roughly the same size at the Boeing 737 or Airbus A320 and typically seats between 165 to 192, depending on cabin layout.

The Brazilian jets span the gap between the two Chinese aircraft, with the E190-E2 carrying 97-114 passengers and the E195-E2, 120-146.

Embraer executives have stressed that current conversations with China, India and Turkey are strategic and not one-sided discussions; the various national governments are actively engaged.

Of course, the possibility of Airbus following the same path with its A220, the E2s' main competitor, can not be ruled out. China is a strategic partner to the European manufacturer, as evidenced by Airbus' first final assembly line outside the borders of its four founding European countries, which opened in Tianjin in 2008. This FAL produced the A320 single-aisle family and was joined by a Completion and Delivery Centre in 2017 for the A330, marking Airbus' first wide-body jetliner centre outside its founding countries.

In terms of crossover jets, Meijer said at the Paris Air Show that airlines were increasingly starting to see the benefits of introducing smaller aircraft that could complement their narrowbodies, pointing to Omani LCC SalamAir as one such

example; in 2022, the Muscat-based carrier ordered six E195-E2s to add to its current fleet of A320s and A321s. Meijer noted that SalamAir had realised it needed an aircraft smaller than the Airbuses. It could offer approximately the exact seat cost but a trip cost around 30% lower than the European narrowbodies.

Meijer echoed Galhardo's belief that the airline sector is approaching a period of replacing its E1 inventories that will likely last until the end of the decade. Additionally, around 1,000 A319s, 737-500s and -700s are fast requiring renewal.

Embraer believes that the cargo sector is another area that holds significant opportunities, which the company's E-Freighter range is well-placed to fill. "At the moment," Galhardo said, "there's a huge focus on small and large turboprops" – such as Cessna's new Courier that will be used as a feeder freighter by FedEx Express and the ATR twin turboprop (both used and new-build) – "and there's a minimal number of crossover-sized freighters in the 10 to 20-tonne capacity segment."

To help fill this gap, Embraer is assembling the first new-build E-freighter, with a service entry planned for 2024 with Kenya's Astral Aviation. And second-hand E1 examples are already being converted to give them a second life as cargo hauliers, with Brazil's Azul the first to take this into service.

Embraer believes this market segment could yield 600 potential sales over the next 20 years. The growth in demand for cargo aircraft, especially in the fast-growing e-commerce sector, means that an estimated 63% of those 600 aircraft will be needed to service this expansion, with just 37% replacing older aircraft. **AI**

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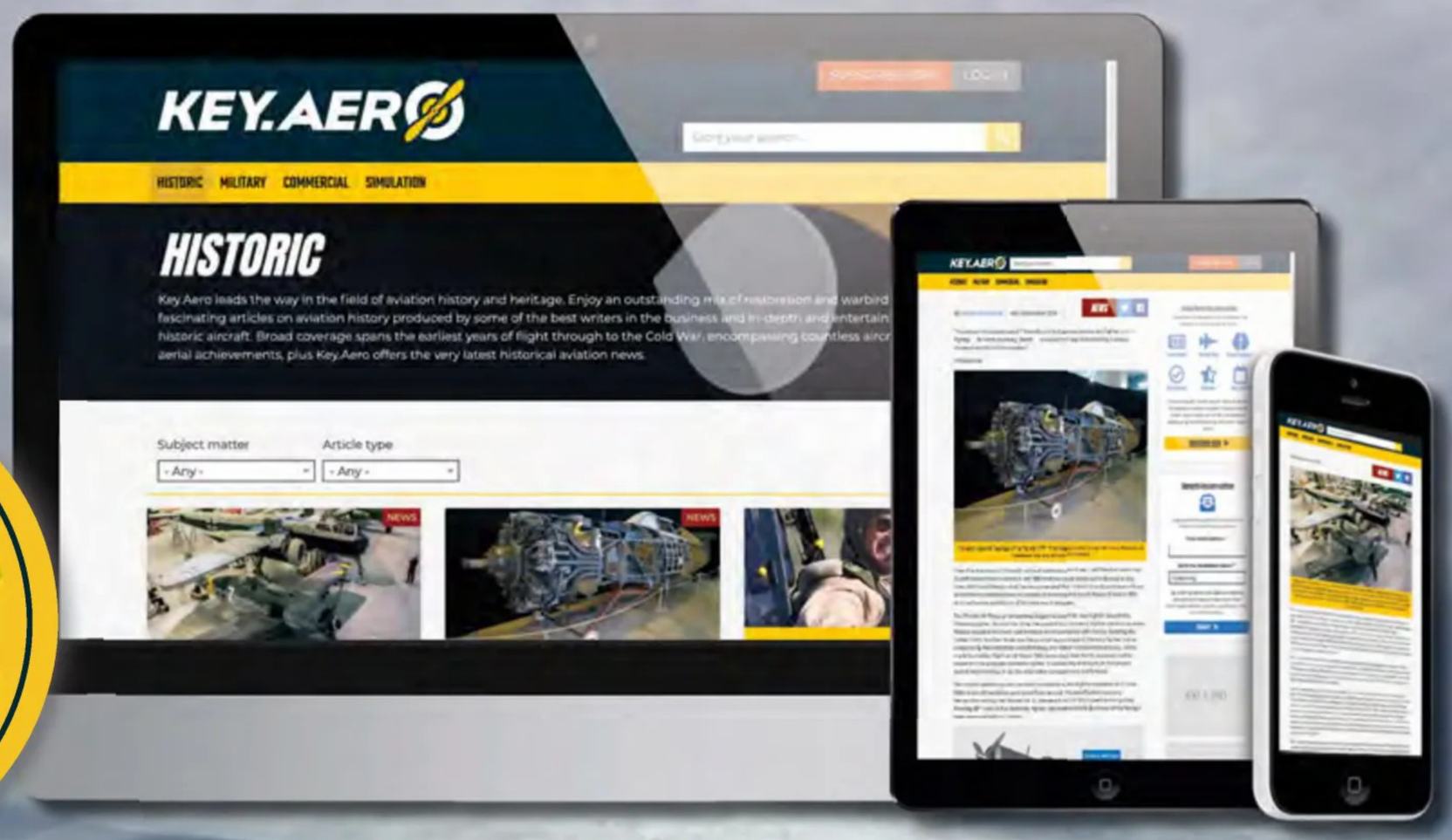

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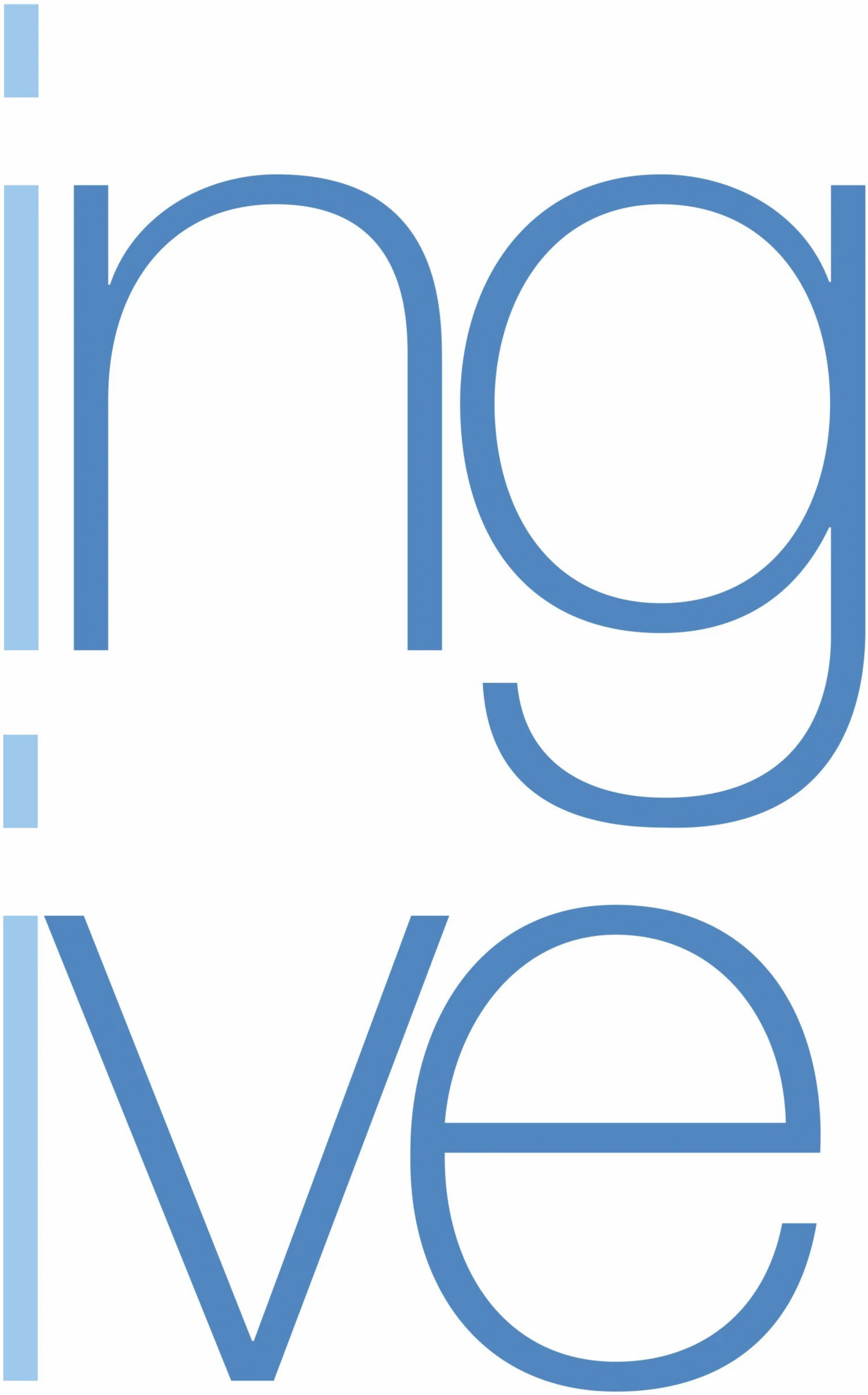
GO

The demand for event-driven live TV is growing inflight, and an increasing number of airlines are avoiding spoilers and offering live television as part of their wealth of library content. **Alex Preston** looks at how live TV is taking flight

DIRECTV has a multi-year agreement with Amazon Prime for the inflight rights to Thursday Night Football
NFL

The date is October 17, 1939. At 20,000 feet above Washington DC, passengers aboard a United Airlines Douglas C-3 aircraft have just received NBC programmes on a television in the cabin sent from a video transmitter 200 miles away, atop the Empire State Building in New York, in an event to mark the 20th anniversary of Radio Corporation of America (RCA).

Media accounts of the time reported that the equipment mounted in the aircraft consisted of a two-camera chain with a relay transmitter operating on 104cm, the shortest wavelength ever used for practical television. The ten small units, each mounted in carrying cases,



weighed about 700lbs.

According to a report from *Broadcasting* magazine, dated November 1 of that year, the journey's highlight came at the end of the return trip as the aircraft approached North Beach Airport, latterly renamed LaGuardia. The TV pictures passengers had so far enjoyed were replaced by live images of their aeroplane landing, thanks to a camera on a companion aircraft.

In a prescient observation, journalist Bruce Robertson said the experiment, conducted jointly by RCA, the National Broadcasting Company, United Airlines and the RCA Manufacturing Company, evoked "prophecies that before long airline passengers will be entertained with telecasts of sporting events or dramatic shows as they travel through the air".

However, it would take until the year 2000 for the now-defunct US domestic all-business airline Legend Airlines to become the first to offer DIRECTV satellite programming on LiveTV seatback screens, followed by JetBlue, which offered up to 24 channels of DIRECTV programming.

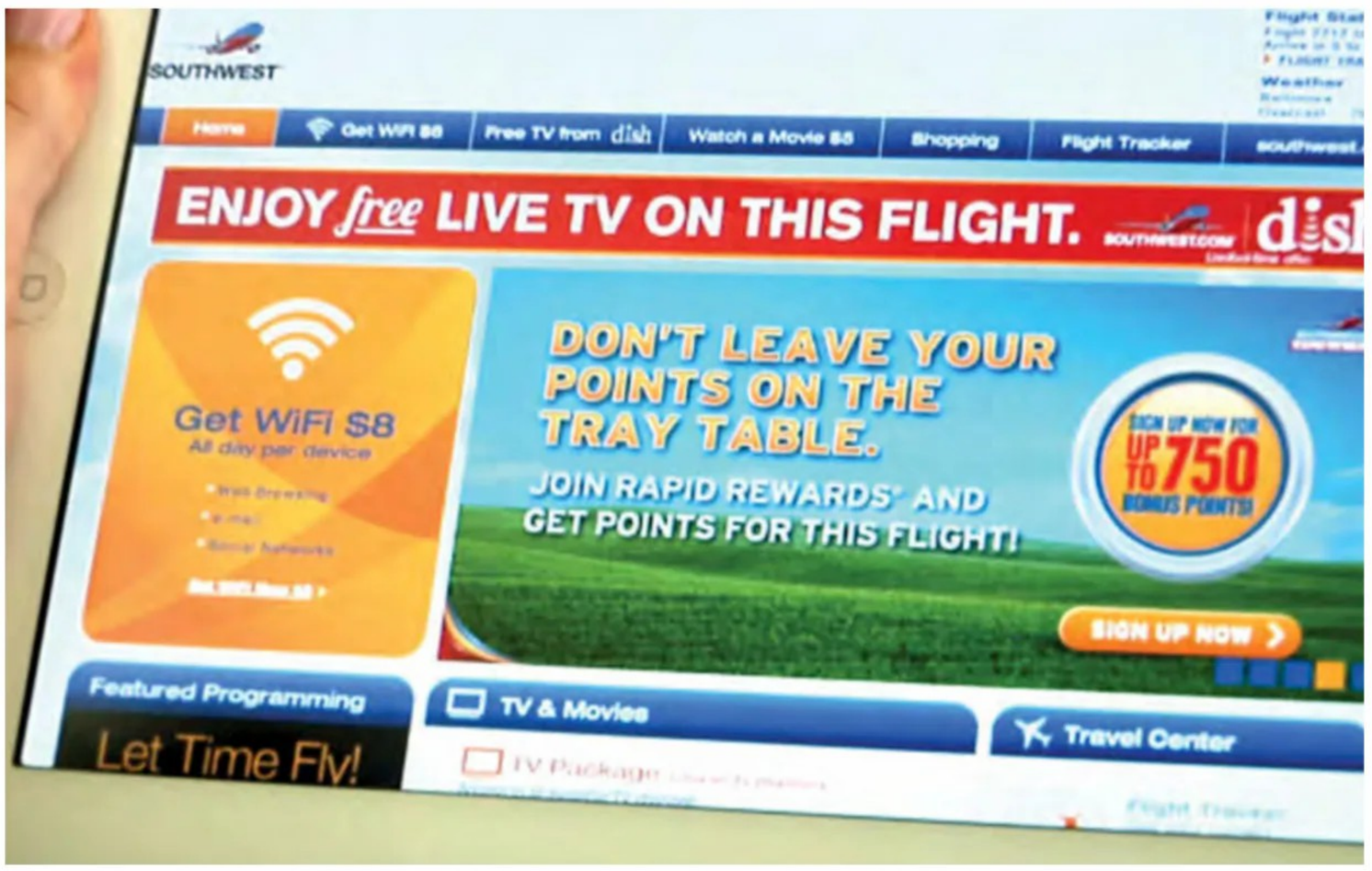
Two years later, JetBlue purchased LiveTV for the cash sum of US$41 million, with the company becoming a wholly-owned subsidiary of the airline and operating as an independent unit managed by existing LiveTV management and marketed under the LiveTV name.

Making the announcement, David Neeleman, chief executive officer of JetBlue, said: "Since its first installation aboard our aircraft in early 2000, LiveTV has proved to be a significant aspect of the JetBlue experience." The acquisition offered JetBlue, as LiveTV's principal customer, the opportunity to directly control the JetBlue product.

In 2014, JetBlue sold LiveTV to Thales for $400 million.

Money talks

In 2019, BBC Global News – the BBC's commercial, international news arm, released its Slipstream research, an online survey completed by 3,000 frequent international flyers. Key findings included 62% of respondents saying that they would be more likely to choose an airline if live TV were available – a figure which rose to 78% for business class passengers and 89% for first-class passengers. Significantly, passengers consistently reported a willingness to pay more for it, with over half of those surveyed happy to pay 5% on top of their standard fare and a third prepared to pay an additional 20%.



Zina Neophytou, vice-president of Out of Home at BBC Global News, commented: "As bandwidth to aircraft increases, there are growing opportunities for airlines to offer passengers an enhanced inflight experience. Our research demonstrates a resounding consumer demand for connectivity and access to live news programming while in the air. As airline capacity grows, we look forward to our continued delivery of BBC World News's unique blend of innovative, impartial journalism."

Despite the apparent commercial benefits of offering live TV, such as providing a better inflight experience and an improved reputation for airlines, mainly being seen as innovative, modern and exciting, few have bought live TV in all its flavours on board.

No additional hardware is required to support Live TV service for aircraft equipped with Viasat, Thales or Panasonic connectivity. Live TV services utilise the on-board modem and wireless access points to distribute content to passenger devices, seatback systems and airline applications. Live TV software and content updates are delivered seamlessly over the air on these providers' high-capacity networks, minimising aircraft out-of-service time and increasing the agility of product enhancements.

Water-cooler moments

Live TV broadcast events bring people together for a shared viewing experience. Five of the top ten most-watched TV programmes in the UK in 2022 were live TV broadcasts. This included the FIFA World Cup (England's quarter-final against France was the most watched programme across all genres), the Platinum Jubilee, and the state funeral of HM Queen Elizabeth II.

Non-scripted programming is big business. According to Ofcom Media Nations 2023, spending on sports in 2022 totalled £614million ($747m), up 4% in 2021 and 26% higher than in 2018, the last year to feature a football World Cup and the Winter Olympics.

In 2021, the National Football League (NFL) secured its latest round of broadcast rights agreements for an eye-watering $113billion over 11 years. Beginning with the 2023 season, Amazon Prime has become the exclusive home of Thursday Night Football, paying $1.2bn per year for the rights offered to airlines via a multi-year agreement with DIRECTV. Elsewhere, ViacomCBS, Fox and Comcast, the owner of NBC, will pay more than $2bn annually for their packages, while Disney, which owns ESPN and ABC, is paying about $2.7bn for its rights.

CBS, Fox, and NBC each will televise three Super Bowls over the upcoming rights period.

Disney is also paying $410m a year across seven years for the National Hockey League (NHL) TV rights. Through its TNT channel, Tuner Sports paid $225m for the rest of the package, which began with the 2021-22 season.

Closer to home, Sky, BT (now via TNT sports) and Amazon extended their arrangement with the English Premier League to screen live matches for a further three years, covering seasons 2022/23 to 2024/25, with a total value

CLOCKWISE FROM TOP:

The Wimbledon Tennis Championship was one of the first sporting events broadcast inflight by Sport 24 in 2012
Sport 24

Live TV satisfies passenger demand for staying connected to real-time news, sporting and hot-topic cultural conversations on the ground while soaring 30,000 feet through the air
Panasonic

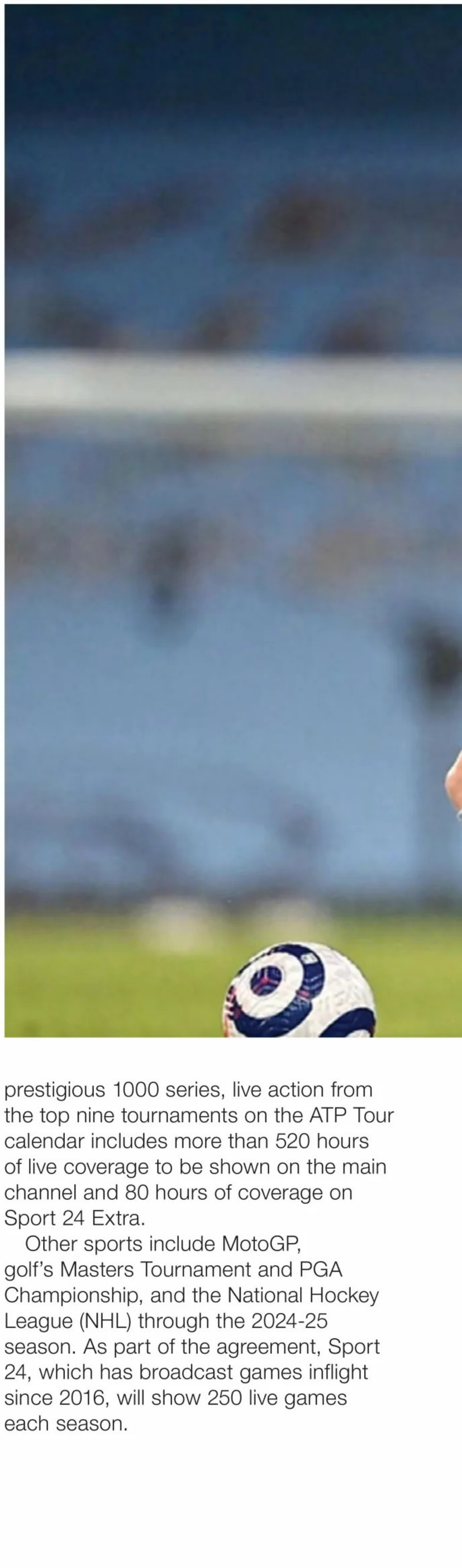
In July 2013, DISH and Southwest began providing free access to live TV on the airline's 400-plus Wi-Fi-enabled aircraft
DISH

thought to be in the region of £5.1bn ($6.2bn).

These on-the-ground spending sprees coincided with the announcement that Panasonic Avionics and IMG had agreed to extend and expand their long-standing relationship to deliver live sports content to the world's leading airlines.

According to Panasonic, sports are so popular with passengers that the company's internal figures from 2018 showed that sporting events made up roughly 40% of live TV viewership inflight.

> *"We are thrilled to bring our world-class, live TV offering to Delta Air Lines and make history with the airline by being the first to offer this type of inflight entertainment"*
>
> Doug Eichler, senior vice-president, DIRECTV Business Solutions



Owned by IMG, Sport 24 is a global, live sports channel available to airlines. Launched in 2012, both Sport 24 and Sport 24 Extra are produced from IMG's production HQ at Stockley Park, near London's Heathrow Airport. It broadcasts 24 hours a day, 365 days a year, connecting passengers to more than 16 hours of premium live content daily.

Under the agreement, Panasonic Avionics has all international inflight rights to the channels. It will exclusively provide IMG's Sport 24 and Sport 24 Extra channels to any airline, regardless of the inflight entertainment system or connectivity network they use.

Speaking at the time, Andrew Mohr, vice-president of digital solutions and services at Panasonic Avionics Corporation, said: "There's nothing quite like the power of live sports, and we are pleased to work with IMG to deliver the world's most exciting sporting events to airline passengers. Watching sports live inflight creates unforgettable moments."

Richard Wise, senior vice-president of content and channels at IMG Media, added: "Panasonic's role as the official provider for our channels is a significant step in the growth of live sport as inflight entertainment. Premium live coverage of the world's major sports tournaments and events is a must-have for airlines wanting to cater to and engage with their customers. We're proud to be part of this exciting development for the inflight industry."

In-seat athletes

Sport 24 broadcast 685 events during its first ten years, featuring 45,000 live hours. As the company enters its second decade, IMG has renewed its broadcast partnership with several sporting bodies for three years. Wimbledon, one of the first tournaments to be shown on Sport 24, will remain on the channel until 2024 at least.

During 2022, the channel broadcast more than 165 hours of live content, while a renewed agreement with Tennis Australia for the Australian Open sees more than 150 hours of live coverage per year. In association with the ATP for the prestigious 1000 series, live action from the top nine tournaments on the ATP Tour calendar includes more than 520 hours of live coverage to be shown on the main channel and 80 hours of coverage on Sport 24 Extra.

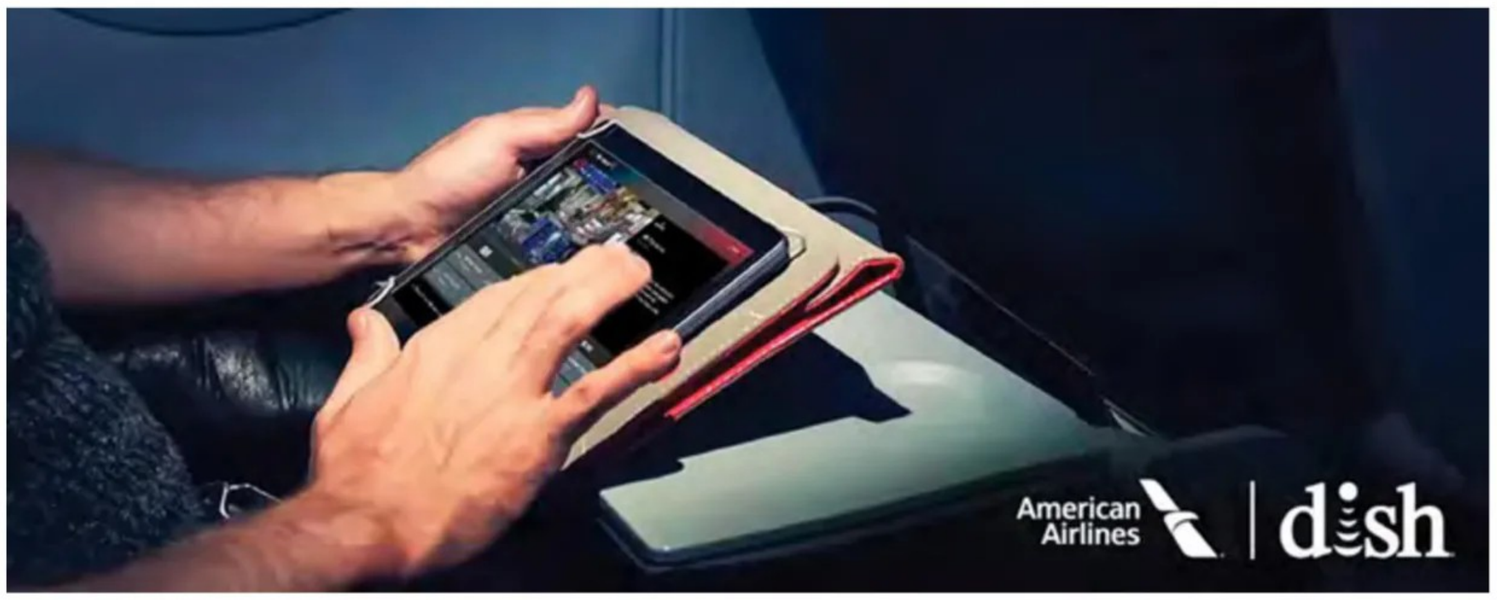
Other sports include MotoGP, golf's Masters Tournament and PGA Championship, and the National Hockey League (NHL) through the 2024-25 season. As part of the agreement, Sport 24, which has broadcast games inflight since 2016, will show 250 live games each season.

In addition to renewing its three-year contract cycles with its existing sports portfolio, IMG has been keen to diversify its international rights portfolio.

In a deal through to 2025, the IMG-owned and operated channels will broadcast more than 150 hours of live Formula One coverage, plus highlights from all race weekends as the sport returns to the channel.

Cricket has also recently joined Sport 24's roster. From October 16 to November 13, 2022, Sport 24 presented 150 hours of live coverage of the Men's T20 World Cup. Indian airline Vistara took advantage of the event to introduce live TV on its Boeing 787-9 aircraft fleet on flights between India and the UK and mainland Europe. Becoming the first Indian airline to offer live TV, in addition to Sport 24 and Sport 24 Extra, passengers can also enjoy BBC News, CNN and CNBC.

IMG also committed to broadcast more than 350 hours of the Men's Cricket World Cup, the quadrennial world championship for One Day



ABOVE:
The Premier League has begun the process of selling rights across four years, starting from the 2025-26 season and ending in 2028-29
Sport 24

TOP:
While live TV is relatively new on domestic aircraft, American Airlines has offered it on many of its international aircraft flights for years
DISH

International Cricket, held in India during October and November 2023. As the Official Airline Partner of the 2023 Men's Cricket World Cup, fans travelling on board Emirates flights during the tournament could watch all 48 matches across India on the airline's ice IFE system.

Other World Cup coverage has included the FIFA World Cup Qatar 2022, during which Sport 24 and secondary channel Sport 24 Extra broadcast more than 125 hours of coverage, reaching a total of five million viewers across 800+ aircraft on airlines including Aeromexico, American Airlines, Emirates (on board more than 200 aircraft), Etihad, JetBlue, Singapore Airlines, Turkish Airlines and Vistara.

The event was streamed on Qatar Airways via Inmarsat's GX Aviation inflight broadband – the first time the connectivity provider has delivered Panasonic Avionics' Live Television.

The channels also showed more than 90 hours of live coverage across 64 matches from this year's FIFA Women's World Cup.

The action never sleeps

In anticipation of this year's Rugby World Cup, Air New Zealand introduced live TV across its widebody fleet of 787 and 777 aircraft in a service trial.

Air New Zealand chief customer and sales officer Leanne Geraghty said the launch of live TV on board would give Air New Zealand customers more entertainment options: "We've been on a mission to give customers the best entertainment options in the skies, and with Wi-Fi enabled across our widebody fleet, adding live sport is a fantastic way to provide customers access to even more content so they never have to miss a minute of the game.

"Just like most Kiwis, we're crazy about rugby, so kicking off the rollout of live sport means they will be able to enjoy live rugby on board and will be able to support their team even while in the air.

"We know many of our customers are passionate sports supporters, but there are a few guidelines we recommend keeping in mind, like staying onside in your seat and keeping neighbours in mind when celebrating."

Sport 24 broadcast 112 live hours across 56 games of the tournament.

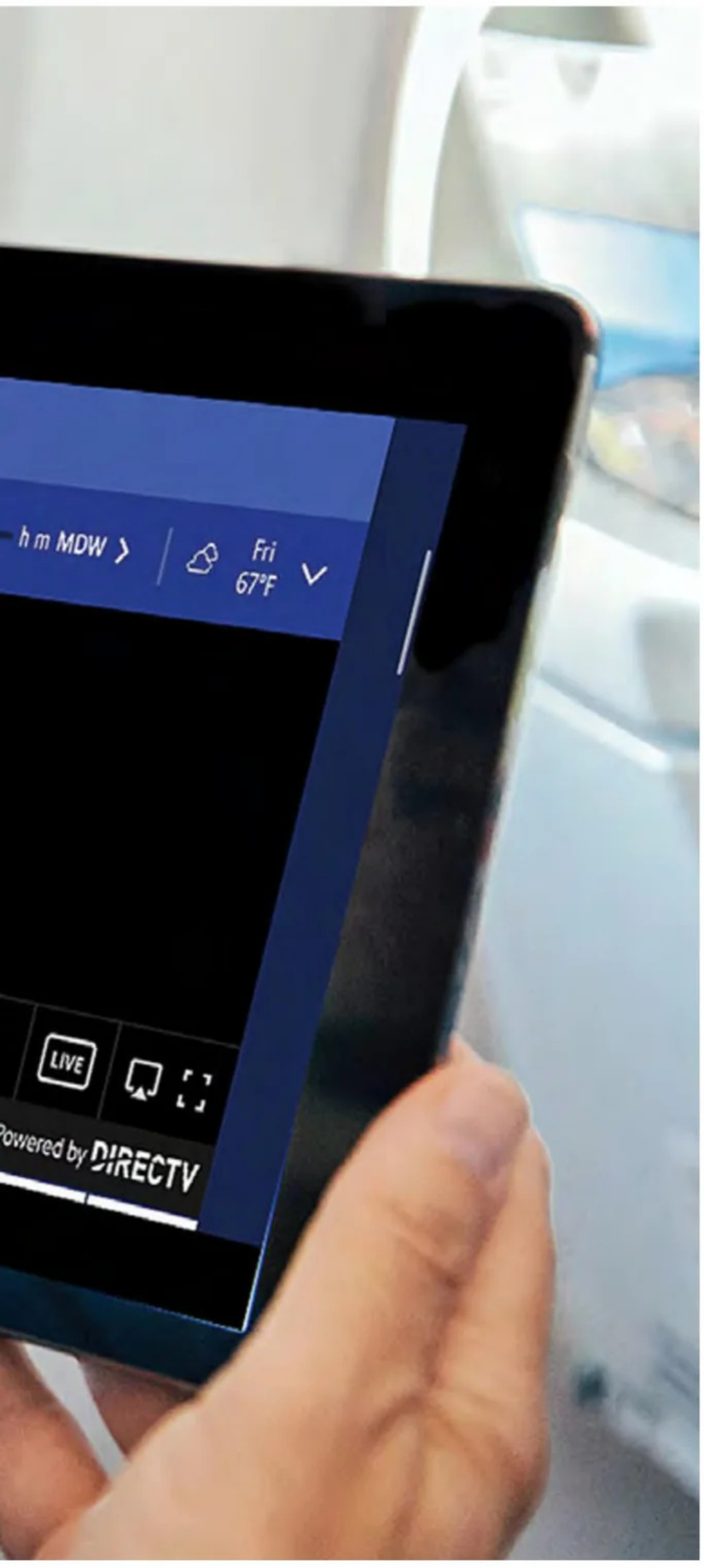
In addition to live sports coverage from Canadian sports provider TSN and its French-language sister channel RDS, Air Canada introduced live TV in November 2022, with live news feeds from 24-hour all-news network CTV News Channel, LCN, Quebec's all-news station and BNN Bloomberg.

Live television is presently available on domestic routes from coast to coast operated with a Live TV-enabled aircraft.

Air Canada was expecting 50% of domestic flights operated by mainline aircraft, namely Boeing 777, Boeing 787, Airbus A330 and Airbus A220 aircraft, to offer Air Live TV by the second quarter of 2023.

"We are thrilled to launch Live TV as the newest addition to our unparalleled on board entertainment," said John Moody, senior director – product design at Air Canada.

"Customers will be able to enjoy content from great Canadian channels in both English and French. Sports fans flying with us can enjoy the exhilaration



CLOCKWISE FROM BOTTOM:

Formula 1 has returned to Sport 24, as the channel diversifies its event offerings
Sport 24

Earlier this year, Southwest introduced the first aircraft into its fleet that is equipped with hardware from Wi-Fi vendor Viasat. The IFE offerings on Viasat-equipped aircraft include live TV provided by DIRECTV featuring channels like CNN, ESPN, FOX and more
DIRECTV

JetBlue was among the earliest airlines to offer live TV programming. A crucial part of its offerings on board, the carrier sold its LiveTV subsidiary to Thales for US$400m in 2014
LiveTV

of watching regular season, playoff and championship games in real time. At the same time, business news junkies will appreciate remaining connected to market trends and current events right from their seats. As we continue elevating the customer experience, we look forward to expanding Live TV to more flights and bringing even more leading content and features in 2024."

Earlier this year, Viasat and DIRECTV announced the launch of a domestic 18-channel TV line-up on select Delta Air Lines Boeing 767-400 aircraft flying select long-haul domestic routes. This domestic LiveTV offering marks the first time a US-based airline has integrated LiveTV into seatback screens on board its widebody aircraft.

"We are thrilled to bring our world-class, live TV offering to Delta Air Lines and make history with the airline by being the first to offer this type of inflight entertainment," said Doug Eichler, senior vice-president, DIRECTV Business Solutions. "As an industry disruptor for nearly 30 years, DIRECTV for Business is proud to take the Delta inflight

experience to the next level, allowing us to reach their customers significantly – one that greatly enhances the passenger experience."

Ekrem Dimbiloglu, managing director of inflight entertainment and connectivity at Delta Air Lines, said: "Live TV is a critical part of the connected living room experience we aim to offer on Delta no matter the customer's destination. We see the aircraft as the ultimate platform for entertainment and discovery, and this milestone brings us ever closer to ensuring that vision is reality on as many routes as possible."

In addition to JetBlue, DIRECTV claims Delta, American and United Airlines as its airline customers – more than 1,600 aircraft. In 2019, United made 100-plus live television channels accessible on 211 Boeing 737 aircraft (more than 30,000 seats) equipped with seatback TV.

Roman Pacewicz, chief product officer, AT&T Business, commented: "We're pleased that United is offering customers complimentary access to live TV on more than 200 of its aircraft so customers can feel like they're sitting in their living rooms enjoying DIRECTV. Whether they want to tune into their favourite primetime show or their favourite sports team, United customers won't miss a moment with free DIRECTV programming."

DIRECTV has launched 14 live channels outside these major carriers, including CNN, ESPN, FOX and more, with Southwest Airlines. In 2013, the airline began working with DISH to provide 13 live TV channels.

DISH would later launch on American Airlines with 12 channels on 100 domestic aircraft. During 2019, free live TV was extended across its long-term mainline narrowbody fleet of more than 700 aircraft. American is already the only US airline to offer live TV on international flights. Kurt Stache, senior vice-president for marketing, loyalty and sales, said: "Our customers have told us they want a living room experience in the air – the ability to watch free entertainment, stream their favourite shows on-demand, charge their phones and stay connected from start to finish during their travels.

"Free live TV on our mainline domestic fleet is the latest step in making that a reality, and it complements the live TV we offer on all of our international widebody flights today."

Fans of college and professional football can get their fix on board aircraft, wherever they're flying Sport 24
Sport 24

Away from the traditional news and sports genres, AERQ has partnered with the Berliner Philharmoniker's Digital Concert Hall, a streaming media service, to allow passengers to enjoy a concert experience at 30,000 feet with the same quality as in their living room. The Berlin orchestra concerts are transmitted live and later become available in a video archive, which now boasts more than 750 complete concert recordings as well as documentaries, films and interviews.

As the BBC's Zina Neophytou said: "When in the air, the most important thing for viewers is choice. Live television is an integral part of this picture." **AI**

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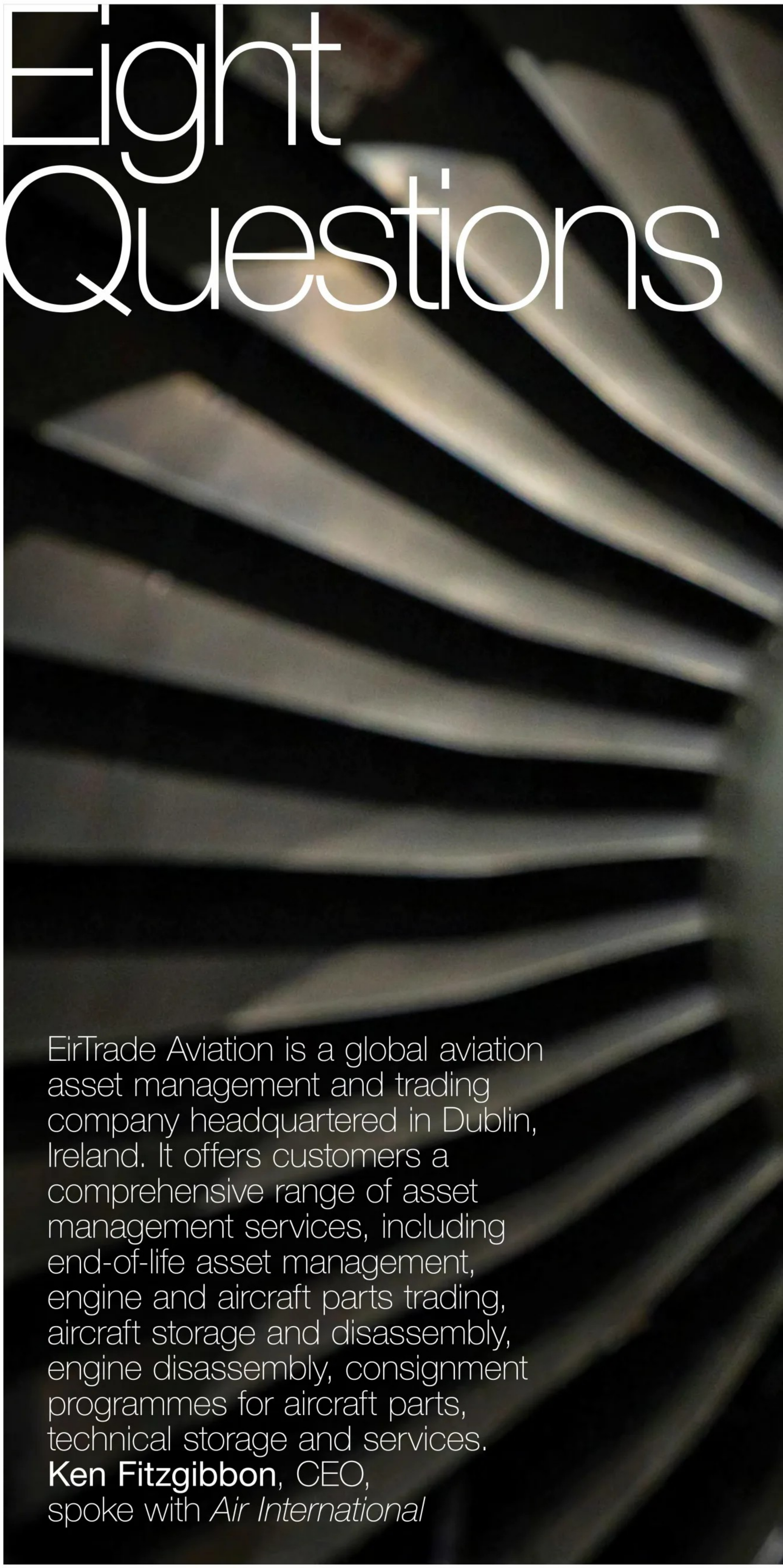
Eight Questions



***Question 1:** What changes have you seen across the commercial aviation industry since the COVID-19 pandemic, if any, and did this impact your work moving forward?*

During the pandemic, many airlines and aircraft lessors were forced to park aircraft due to early lease terminations, cancellation of deliveries and the overall illiquidity of the market at the time. This created opportunities to acquire younger aircraft for disassembly, further expanding our inventory pool.

Over the past couple of years, we have taken time to examine the extra services we could provide that would benefit our customers and broaden our appeal. As a result, we opened an engine teardown facility in Dublin, secured Part 145 line-maintenance approval at our hangar in Knock (Ireland West Airport), opened a new facility in Dallas, focused on deepening our partnerships with the lessors of aircraft and engines

worldwide; and widened our global representations in Europe.

The shortage of available manpower since COVID-19 has significantly impacted the industry. Many people left the industry or took early retirement during the pandemic, and as businesses scale back up their operations, this personnel supply is no longer available. Now that aircraft utilisation has recovered, the manufacturers (OEMs) cannot produce new aircraft quickly enough due to supply chain delays, so airlines are taking on older aircraft to meet their demands for growth. These aircraft need engineering and repair shop support, plus spare parts provision – and all of these aviation businesses also have staff deficits.

EirTrade Aviation's experienced team and wide range of services positioned EirTrade with the opportunity to become the first USM (used serviceable material) company to disassemble two B787-8 aircraft. This has allowed EirTrade to become the leading independent supplier of B787 material.

***Question 2:** EirTrade Aviation has just disassembled its first Boeing 787-8, but there is talk across the industry that fewer airframes are becoming available teardown by MRO companies; what are your views on this, and should it be a cause for concern by MRO companies?*

At the end of a lease, a lessor must decide about the aircraft. Should the aircraft be transitioned to a new lessee? Is there still green time on the engines? Or should the aircraft be traded? However, if the maintenance costs are too high, the aircraft might be more suited for disassembly. There are many of these opportunities in the marketplace, creating a strong future pipeline, so we are not concerned about the lack of teardown stock.

In fact, since the pandemic, many aircraft have been parked at airports without engines, and these need to be dismantled.

At Shannon Airport in the west of Ireland, for example, there are several, yet the airport authorities require operators to obtain planning permission to undertake the work; this is somewhat inexplicable and we'd like to see airports being more accommodating to help clear this backlog.

***Question 3:** Regarding engine inventory and overhaul, what models are proving the most popular and in demand? How are you meeting this demand?*

All engine material is in high demand currently. At EirTrade Aviation, we focus on a wide range of narrow and widebody aircraft and engines.

To meet the demand, we need to buy more engines, and these are sourced through the tendering opportunities we are invited to participate in.

Here, we rely on the skills of our team to identify the right assets for our portfolio and keep our inventory current and revolving.

During COVID-19, we also looked at new technologies that would improve efficiency and release our people from 'spreadsheets'. We pride ourselves in being a data-driven business to facilitate an efficient decision-making process.

***Question 4:** With the requirements for commercial aviation to become more environmentally friendly, from engines to materials, what plans and processes does EirTrade Aviation have in place moving forward?*

In the aviation industry, having the right approvals and accreditations is essential to instil confidence in our customers. We are members of AFRA (Aircraft Fleet Recycling Association), which outlines the best practices and procedures for disassembling aircraft.

At EirTrade, we can dismantle a narrowbody aircraft in 15 days, so all our processes are streamlined and very carefully managed to achieve these turn-around times. Everything we disassemble is in keeping with industry best practices. Still, we support innovation in carbon fibre recycling and encourage companies or individuals developing new processes to talk to us.

We have also innovated at our facility and continually look for ways to improve our work. Last year, we designed and built a special cradle to support the narrowbody fuselage during teardown. This enables the high-value components like the landing gear to be removed at the beginning of an aircraft disassembly, realising value quicker.

***Question 5:** Can you explain the process of sourcing aircraft, engines and parts following an initial request from the customer? What can be the challenges during this process?*

The key is identifying and acquiring the right asset under the correct terms. If we do this, it paves the way for every project to be successful.

Finance is the biggest challenge, as it is for most businesses. Ensuring that secure funding is readily available means we can take advantage of opportunities at the

Have you found a shift from one to the other recently, as operators deal with a global financial crisis, and in terms of each, can you discuss the respective benefits?

It depends on the operators and what they need to efficiently and profitably run their businesses. Both options have their place. The decision centres around what capital they have and how best to work with it. And this can change as their businesses evolve.

For example, Ryanair started leasing all their aircraft and engines, but now they are cash-rich they own all their assets, which places the inherent value firmly into their business.

CLOCKWISE FROM TOP LEFT:
EirTrade Aviation has become the leading independent supplier of Boeing 787-8 parts to the industry
All images via EriTrade

A specially designed cradle allows the undercarriage to be removed at the start of the teardown process

EirTrade Aviation's headquarters is located in Rathcoole, County Dublin, Ireland

Engine stand leasing and sales have become a significant part of EriTrade Aviation's current business

right time. Businesses are thriving in the aviation aftermarket. Maintenance, repair, and overhaul industries attract investors, and the returns are promising.

Question 6: How would you like to see the industry develop over the next five to ten years? What changes must be implemented across commercial aviation to improve your work?

I feel the industry is still quite cautious and is focusing on what it knows how to do well. At the same time, the recovery steadily grows, and the supply-chain problems and workforce shortages resolve themselves. Advanced systems and robotics will inevitably be disruptors/improvers, but that will take time.

One thing that is true to say, however, is that 'money' makes the magic happen. Without investment to spearhead change, developments will be slow and steady, and no quantum leaps are envisaged.

Question 7: EirTrade operates both a lease and sale side across its sectors.

Question 8: How do you spend your free time away from aviation? Do you have any hobbies or interests?

I have a great interest in cars and motor sport generally. Even though I fly a lot for business, I still love to travel and explore new places and cultures. **AI**

JANUARY ISSUE **ON SALE DECEMBER 13**

A US Marine Corps CH-53E airlifts an M777 howitzer Cpl Jacob Wilson USMC

The UK's ATC network gets an extensive overhaul NATS

Next Month

Heavy lifting Helicopters have become a critical part of every military operation, moving supplies and troops to and from the battlefield. We look at the new platforms being developed for the future

Traffic management In the UK, air traffic control is introducing major reorganisation, revised procedures and new technology. Mark Broadbent examines the changes taking place

Islander revamped The prospect of a viable hydrogen-electric powered commercial aircraft may not be too far away, according to CEO Paul Hutton of Cranfield Aerospace Solutions

Air New Zealand will soon introduce SkyNest sleeping pods into its 787s and is partnering on electric-hybrid turboprops for domestic flights. Chief customer and sales officer Leanne Geraghty explains all

The venerable Britten-Norman Islander is destined for a bold new role Cranfield Aerospace Solutions

Introducing new concepts is the way ahead says Air New Zealand's Leanne Geraghty Air New Zealand

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